POWER

Volume 59 New York, June 10, 1924 *No.* 24

Legislating Away Natural Resources

THIS country came out of another war years ago.

There were few, if any, millionaires made in that war.

We came out of it a loosely coordinated group of sovereign states with no great national industries and no machinery for converting our abundant natural resources into wealth.

And in the councils of the nation there was a superman. He had done wonders in business and finance, and the statesmen of Europe sat at his feet and marveled.

And this superman had a wondrous vision—the creation of a great industrial community to supply with manufactured goods this country, if not the world.

All the cotton yarn in the country had been spun by hand. Cotton goods sold at fifty cents a yard. He incorporated the Society for Establishing Useful Manufactures, to run great factories for the production of cheap clothing and other useful and legal products, furnishing employment to thousands, making commerce for our shipping and bringing back in payment the wealth of other peoples—it was a glorious dream.

And it took. Its charter designated 10,000 shares at $100 each. The United States or the State of New Jersey was authorized to subscribe to the amount of $10,000 by lottery. Men of means were dazzled by its possibilities, and "contributors" subscribed half a million of dollars. The House of Assembly and Council gave the promoters of the plan a charter containing plenary powers.

And as a consequence everybody who takes water from one of the rivers in Northern New Jersey or any of its tributaries, pays tribute to the heirs and assigns of the beneficiaries of that grant, and no North Jersey municipality wrestles with the problem of its water supply without running up against a paper wall founded upon that act.

Supermen are mortal, and it takes a wise legislator to see one hundred years ahead.

F. R. Low

Mixed-Pressure Turbine versus A New Steam Plant

By FLOYD S. YONTSEY
Consulting Engineer, Collinsville, Illinois

TO SUPPLY power to a new mine four and one half miles distant, a mixed-pressure turbine in the home plant was selected over a steam plant at the new mine or additional high-pressure capacity in the original plant. Salient features are the condenser and cooling water installations.

IN THE early part of 1922 the management of the St. Louis Smelting & Refining Works of the National Lead Company at St. Francois, Mo., found it necessary to open another mine, known as No. 7 Shaft, which is about 4½ miles from the original mine. The company is engaged in lead mining and the concentration of the ore for shipment to the smelter. The home property consists of six mining shafts, an ore concentrator, the necessary power plant, machine shop, etc.

In the power plant the equipment consists of eight 2,600-sq.ft. and two 5,000-sq.ft. boilers of the water-tube type, two cross-compound Corliss air-compressor units, four cross-compound Corliss generating units, and one single-cylinder Corliss generating unit used in emergency, all totaling 4,470 i.hp., as rated at full load.

The two air-compressor units were built for non-condensing operation, but provision was made to operate the other units condensing. As a point of interest one of these compound condensing units has operated 165,000 hours in the last 22 years, or about 19 years continuously. It wo- out two high-pressure cylinders,

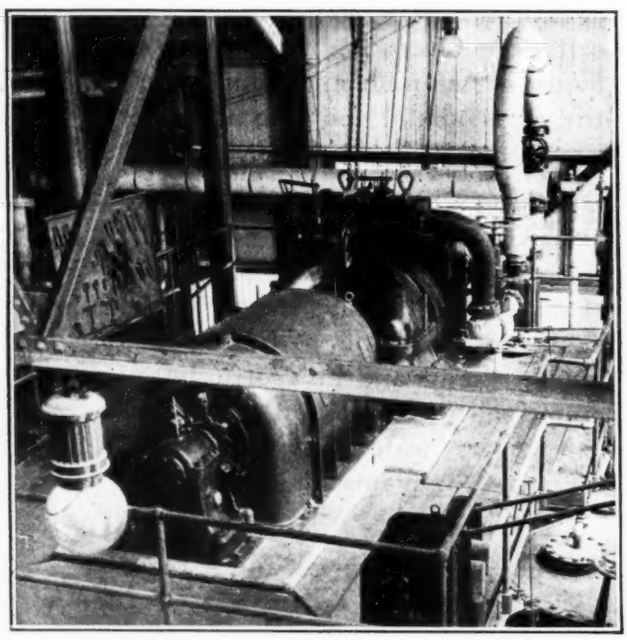


Fig. 1—Mixed-pressure turbine installation

but the original low-pressure cylinder is still in use. All the machines are in good condition and fit for many years of service.

Since the proposed new mine was 4½ miles away, it was obvious that it would be necessary to furnish power by alternating-current transmission from the home plant or build a steam-operated plant at the new mine. Estimates showed that a steam plant at No. 7 mine would cost 25 per cent more and would require three shifts of boiler and engine-room crews. Furthermore, small steam units used locally would show higher steam consumption than obtaining in the original plant, and

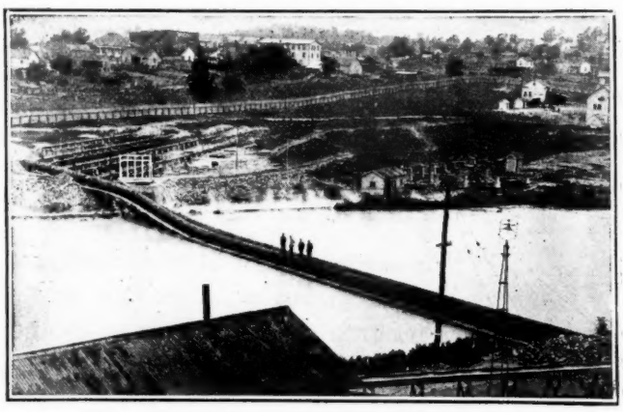


Fig. 2—Condenser cooling-water system

the additional men employed would require added investment in housing for them. The decision was decidedly in favor of transmitting power from the home plant, and with this decision came the opportunity of improving the steam economy of the whole plant. Other mining companies in the district transmitted three-phase 60-cycle current at 6,600 volts, so it was decided to make the new line conform with the general practice.

Three plans were considered seriously: First, to install an exhaust-steam turbo-generator to run on the exhaust from the old units. This had the disadvantage that the loads on the proposed turbine and on the old machines did not fluctuate in unison, which would mean that at times there would be too much exhaust steam for the turbine and the excess would go to waste, while at other times there would not be enough exhaust steam to pull the load on the turbine.

The second scheme considered was to install a high-pressure condensing alternating-current turbo-generator capable of carrying the home demand and the new load at No. 7 mine. The principal objection was an increase of investment of about 60 per cent without sufficient saving in steam to pay for it.

The third plan, and the one adopted, was to install a mixed-pressure turbo-generator having a capacity of 1,562 kva., or 1,250 kw. at 80 per cent power factor. The steam end of this unit is of the regular high-pressure condensing design, with three stages of the low-pressure blading removed at the point where the low-pressure steam is admitted. This permits the passage of 43,000 lb. of steam per hour through the low-pressure blading when the exhaust steam is admitted at

16 lb. abs. pressure and the vacuum is 28 in. When running mixed pressure, the total steam must not exceed this amount.

If at any time it is desired to make this machine a standard high-pressure turbine, the three rows of low-pressure blading can be reinserted, reducing the steam consumption by 0.85 lb. per kw.-hr. As it is now arranged, the turbine has carried a momentary peak of 1,800 kw. To eliminate the exhausting of steam from the reciprocating units on turbine overloads, it was decided to take enough steam from the reciprocators to pull about 950 kw. on the turbine, and for any load in excess of this limit admit high-pressure steam to the turbine through the high-pressure blading.

In the accompanying diagram, Fig. 3, is shown the distribution of steam and the electrical layout. The

Several years previous, the company had purchased a barometric condenser to replace the old condenser on the Corliss engines, but it had not been set up. This condenser was built for 90,000 lb. of steam per hour at 26 in. vacuum and would handle easily 43,000 lb. per hour at 28 in. vacuum. The condenser head was connected to the turbine by a special nipple and expansion joint, almost all the other fittings being on hand. The tail pipe was carried down and connected to the evacuating pump set 8½ ft. below the bottom of the condenser head, thus giving the necessary head on the pump suction. This pump delivers the condensing water directly to the spray heads, and the condenser lifts the cooling water 16 ft. from the spray pond.

Air is pumped from the condenser by two steam air ejectors in series with a surface inter-condenser between

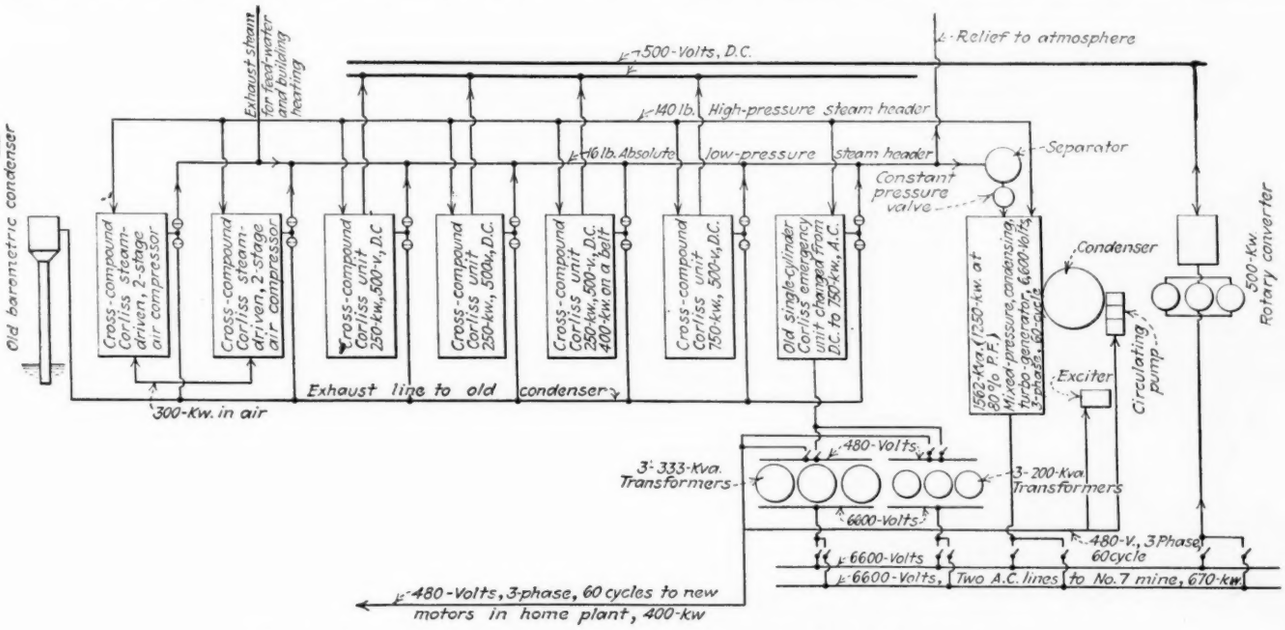

Exhaust steam for feed-water and building heating
500-Volts, D.C.
Relief to atmosphere
140 lb. High-pressure steam header
16 lb. Absolute Low-pressure steam header
Separator
Constant pressure valve
Old barometric condenser
Cross-compound Corliss steam-driven, 2-stage air compressor
Cross-compound Corliss steam-driven, 2-stage air compressor
Cross-compound Corliss unit 250-kw., 500-v., D.C.
Cross-compound Corliss unit 250-kw., 500-v., D.C.
Cross-compound Corliss unit 250-kw., 500-v., D.C. 400-kw. on a belt
Cross-compound Corliss unit 750-kw., 500-v., D.C.
Old single-cylinder Corliss emergency unit changed from D.C. to 750-kw., A.C.
1562-Kva. (1250-kw. at 80% P.F.) Mixed-pressure, condensing, turbo-generator, 6,600-volts, 3-phase, 60-cycle
Condenser
500-Kw. Rotary converter
Exciter
Circulating pump
300-Kw. in air
Exhaust line to old condenser
480-Volts
3-333-Kva. Transformers
3-200-Kva. Transformers
6600-Volts
480-V., 3 Phase, 60 cycle
6600-Volts
6600-Volts, Two A.C. lines to No. 7 mine, 670-kw.
480-Volts, 3-phase, 60 cycles to new motors in home plant, 400-kw

Fig. 3—Layout of old plant, showing steam and electrical connections

turbine rating is reached on peak loads of short duration, which do not overload the generator. The power factor ranges between 90 and 95 per cent. A peak load of 850 to 950 kw. on the engine units produces 28,000 to 32,000 lb. of exhaust steam per hour for the turbine. The 500-kw. rotary gives a convenient method of controlling the balance between the alternating-current and the direct-current loads and helps the 750-kw. emergency unit pull the alternating-current load when the turbine is out of service.

In selecting the condensing equipment for the turbine, a surface condenser was eliminated for the reason that the circulating water available was not suitable. This left for consideration either the low-level jet or barometric type. The usual barometric installation could not be employed as there was insufficient headroom, so proposals were requested on low-level jet equipment.

In tabulating these proposals, low efficiency guarantees for the centrifugal pump evacuating the condensing water were noticeable. Upon inquiry, it developed that the lower efficiency was caused by the low static head effective on the pump suction, and if this head could be increased, the pump efficiency would be considerably higher. With this information the condenser problem was solved in the following manner.

them. Between 28 and 29 in. of vacuum, based on a 30-in. barometer, is obtained under regular operation.

Another interesting feature of the installation was the working out of the condensing-water spray system. There was no suitable location for a spray pond nearer than 475 ft. from the turbine, and the pond had to be put on a hillside. This was done by making a crescent-shaped dam of rockfill, faced on the water side with clay loam. The rockfill dam was selected for the reason that concrete or masonry was too expensive and with an earthen dam a sudden leak would wash out a large section. In the case of the rockfill type a leak only washes away a small amount of loam and is easily repaired, the rockfill itself remaining intact.

About 1,900 ft. of main and distributing lines was used, consisting of 36-in. lines from and to the spray pond and four pipes of 18 in. diameter to distribute to the spray nozzles. These pipe sizes seem large to handle on an average 4,000 gal. of water per minute. All of the piping, except the fittings is made up of redwood staves banded to withstand a head of 40 ft. The total friction-head loss over the entire system is estimated at ¾ ft. or ⅓ lb.

The present system has capacity to serve two more high-pressure turbines of 1,562 kva. capacity by adding

more spray heads, and even then the friction head, exclusive of the sprays, should not exceed 3 ft. or 1.29 lb. The same amount of money spent on steel piping would have given capacity for only one turbine and the loss in friction head would have been about 4 or 5 ft., with the chance that steel pipe would not have lasted so long.

Prevailing winds in the hot weather are from the south, and from the northwest in the fall, winter and spring. The four 18-in. distributing lines were laid east and west, and spaced on 25-ft. centers with the spray pipes from the top of these lines spaced 10 ft. apart. This arrangement favored the summer winds and intercepted the maximum air volume the pond space would permit.

A concrete forebay built in the dam was provided with gates, trash screen and a 4-ft. rectangular weir to measure the water just before entering the suction pipe leading to the condenser. This pipe was laid well below the level of the spray pond, with the certainty that no air would be drawn in and carried to the condenser, and as an additional precaution a tunnel was cut into the hill at the turbine end and both in and out pipes taken through it, so that only 20 ft. of the suction line is subjected to a negative pressure.

A succeeding article will be devoted to an improvised method of testing the turbine unit and the jet condenser.

Oil Engines in Small Pumping Plants

The supplying of water to communities is one public function that is almost invariably left to the municipal authorities. Public-utility corporations may control the lighting system, street railways, gas works and like enterprises, but the water works is generally left alone. This may be due to the fact that operating charges are usually small compared to the fixed charges and consequently amalgamation with or absorption by a larger system does not bring with it the reduction in total charges that frequently occurs in the case of lighting systems.

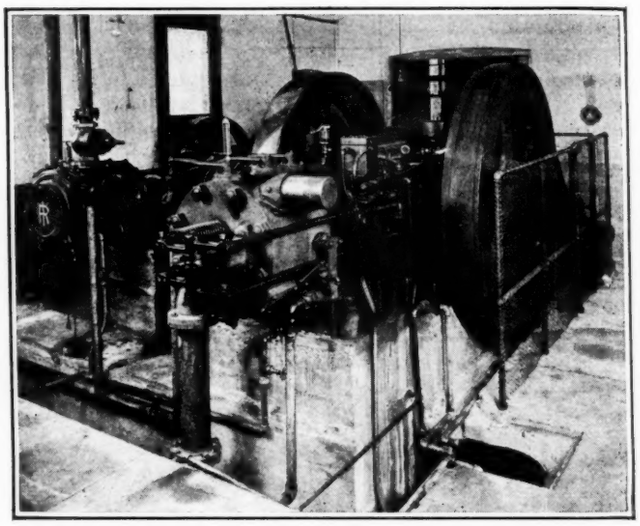
However, the possibilities of reduction in pumping costs per million gallons are far greater than might be surmised. While there are hundreds of plants still making use of direct-acting steam pumps, the tendency in many cases is to replace these by oil-engine units.

Westbury, N. Y., a community twenty miles from New York City, has been supplied with water from a municipal plant for a number of years. Various types of prime movers have been used, including producer-gas and kerosene engines. While repairs were high, still the operating costs under adverse conditions were less than if purchased current had been used.

In 1922 the water department was faced by the problem of either spending a large sum to overhaul the kerosene engines then in use or installing a new and more efficient unit. As the solution a 100-hp. solid-injection oil engine was installed, being direct-connected to a 12x10-in. double-acting air compressor. This compressor supplies air to the deep-well air lift, the water discharging from the well flowing into a catch basin. A centrifugal pump, which is not shown in the illustration, is belted from the engine flywheel and lifts the water from the basin to a standard-type steel tank placed on a 40-ft. steel tower located at one side of the power plant. A small gasoline engine direct connected to an air compressor is used to supply the engine air-starting tanks in case of trouble to the large compressor.

The plant has a capacity of 300 gal. per min., the compressor and centrifugal pumps being of equal capacity to permit balancing of the system.

The station cost of pumping, considering the small capacity, is low, the hourly operating charges being:



One hundred horsepower oil engine and compressor

Labor, $1; lubricating oil, 5 cents; fuel oil, 8 cents per gallon, 40 cents; total, $1.45. As 30,000 gal. is pumped per hour, the plant costs are 4.8 cents per thousand gal.

Pulverized Fuel in England

The use of powdered fuel is not as yet taking hold very strongly in Great Britain or on the Continent, although there is considerable interest being shown in the subject. While most engineers recognize that coal can be satisfactorily burned in the pulverized state, they are rather hesitant about spending the money for the additional installation cost and contributing to development costs and new maintenance problems at a time when money is rather scarce.

The Borough of Hammersmith in London has an old station where they have lately installed two 7,500-sq.ft. Stirling boilers with a Holbeck system of powdered fuel. This is the only commercial station burning powdered fuel that the writer visited in England.[1]

These boilers are designed for 200 lb. steam pressure and 600 deg. temperature, and have two burners on each boiler. The average evaporation of the two boilers is about 45,000 lb. of steam per hour. Approximately 85 tons of coal per day is being burned, with an average heat value of 9,000 B.t.u.; the fuel is a 27 per cent volatile coal with 5 to 10 per cent moisture and about 15 per cent ash. No attempt has yet been made to fire the coal without drying it. The pulverizing plant consists of one 5-ton Bonnot mill and one 5-ton Sturtevant mill. The average requirement for auxiliary power is 25 kw.-hr. per ton of coal. It is estimated that 4 lb. of air per pound of coal will be supplied to the burners. About one-quarter of the air required for combustion is carried in with the powdered fuel and the remainder comes in at a temperature of about 280 deg. from the air preheater, giving an average combustion air temperature of about 210 deg.—*From Report on Foreign Power Developments, Prime Movers Committee, N. E. L. A.*

[1]The other stations, Peterborough and Philadelphia, are using pulverized coal.

Auxiliary Exhaust Valves Versus Additional Clearance in Back-Pressure Unaflow Engines

By PROF. P. LANGER*

IT IS characteristic of steam-engine operation of today that engines run more frequently non-condensing than condensing. The steam is exhausted at temperatures and pressures that are needed for heating processes of various kinds. Frequently, heat is required only at certain periods, while at other times the lack of heat makes it advisable to run the engine condensing. Furthermore, the possible variation of the back pressure has to be taken into consideration. One way to adapt the unaflow to these variable conditions is to provide an additional clearance space. Another way is to provide auxiliary exhaust valves which are closed at suitable points such that with varying back pressures the

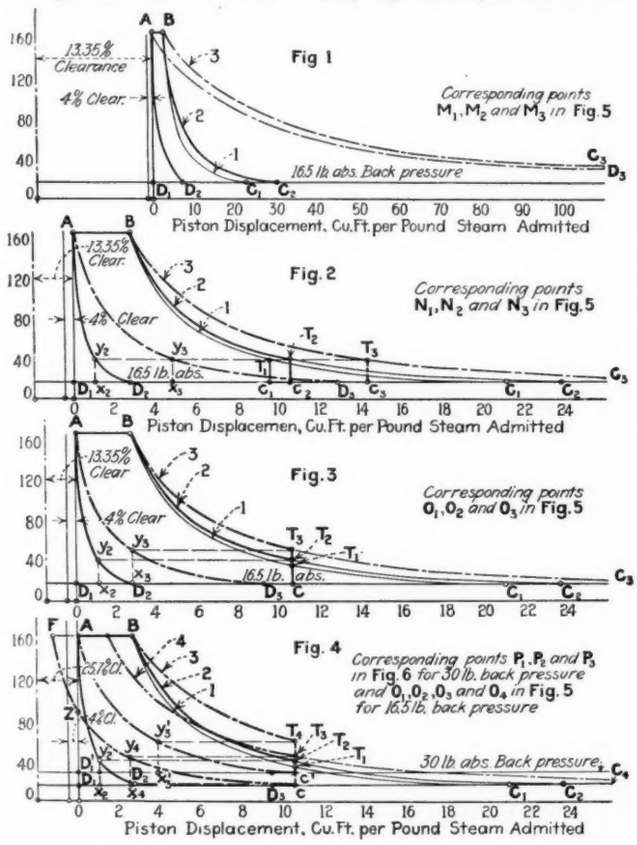


Fig 1
13.35% Clearance
4% Clear.
Corresponding points M1, M2 and M3 in Fig. 5
165 lb. abs. Back pressure
Piston Displacement, Cu.Ft. per Pound Steam Admitted
Fig. 2
13.35% Clear.
4% Clear
Corresponding points N1, N2 and N3 in Fig. 5
165 lb. abs.
Piston Displacemen, Cu.Ft. per Pound Steam Admitted
Fig. 3
13.35% Clear
4% Clear
Corresponding points O1, O2 and O3 in Fig. 5
165 lb. abs.
Fig. 4
25.7% Cl.
4% Cl.
Corresponding points P1, P2 and P3 in Fig. 6 for 30 lb. back pressure and O1, O2, O3 and O4 in Fig. 5 for 16.5 lb. back pressure
30 lb abs. Back pressure
Piston Displacement, Cu.Ft. per Pound Steam Admitted

Figs. 1 to 4—Indicator diagrams with different clearances and expansions

compression pressure does not exceed the boiler pressure.

The objection has been raised that auxiliary exhaust valves mean a departure from the unaflow principle. This is true but only to a minor extent. Under normal conditions more than one-half of the working steam leaves the engine through the ports. The major portion of the expanded steam, therefore, cannot cause any undesirable heat interchange between the walls and the incoming steam, for the exhaust ports and the adjacent parts of the cylinders are swept over by the piston before the new charge of steam enters the cylinder.

It is well to compare these two methods of adapting

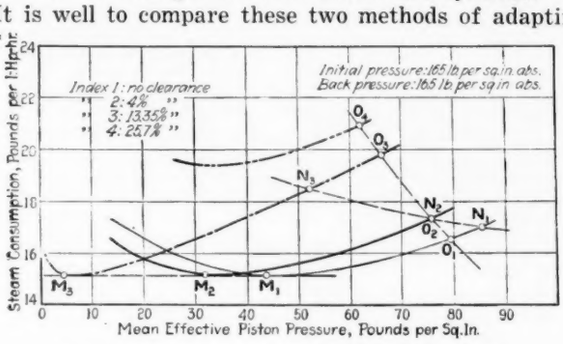

Index 1: no clearance
2: 4% "
3: 13.35% "
4: 25.7% "
Initial pressure: 165 lb. per sq.in. abs.
Back pressure: 16.5 lb. per sq.in. abs.
Steam Consumption, Pounds per I.H.P.hr.
Mean Effective Piston Pressure, Pounds per Sq.In.

Fig. 5—Steam consumption with 16.5 lb. at back pressure

the unaflow engine to back-pressure, or atmospheric-exhaust, operation. The comparison will be based on the computation of the relative steam consumption and mean effective pressures of four engines as follows:

Case 1. Engine having no clearance.

Case 2. Engine provided with auxiliary exhaust valves, which close at a suitable point to bring the compression pressure up to boiler pressure at the end of the stroke, clearance being 4 per cent.

Case 3. Engine provided with an additional clearance space and no exhaust valves. The compression starts at 10 per cent of the stroke after dead center. Compression up to boiler pressure. Clearance 13.35 per cent for 165 lb. per sq.in. abs. initial pressure and 16.5 lb. per sq.in. abs. back pressure; clearance 25.7 per cent for the same initial pressure and 30 lb. per sq.in. abs. back pressure.

Case 4. Engine provided with an additional clearance space of 25.7 per cent for 30 lb. per sq.in. abs. back pressure and operated at 30 lb. per sq.in. abs. back pressure.

The essential points in comparing the two ways of adapting unaflow engines to atmospheric-exhaust and back-pressure operation are the influence of the clearance space upon the steam consumption and the mean effective pressure at a definite steam consumption. The curves in Figs. 5 and 6, showing the steam consumptions per horsepower-hour as ordinates and the mean effective pressure as abscissas, are the characteristic curves upon which the comparison is to be based.

The maximum output of work for one pound of steam admitted to the engine will be achieved by fully expanding the steam in the cylinder from the given initial pressure to the given back pressure. The output is the same regardless of the amount of clearance space, pro-

*Aachen, Germany.

vided the compression is from the back pressure to the initial pressure and the piston displacement be of a sufficient volume to permit both the steam admitted to the engine at each stroke and that inclosed in the clearance space to expand down to the back pressure.

In Fig. 1 each of the areas ABC_1D_1 ABC_2D_2 and ABC_3D_3 represents 130,700 ft.-lb. as the work done by one pound of saturated steam admitted to the engine and completely expanded from 165 lb. abs. initial pressure to 16.5 lb. abs. back pressure.

The corresponding-steam consumption,

$$\frac{19{,}800{,}000 \text{ ft.-lb. per 1 hp.-hr.}}{130{,}700 \text{ ft.-lb. per 1 lb. steam}} = 15.15 \text{ lb. steam per 1 hp.-hr.,}$$

will be the same for Cases 1, 2 and 3.

The mean effective pressure, which is

$$\frac{\text{work (ft.-lb. per 1 lb. steam)}}{144 \times \text{displacement (cu. ft. per lb. steam)}},$$

works out for the several engines as follows:

Case	1	1	3
Clearance, per cent	0	4	13.35
Mean effective pressure, lb.	43.3	31.7	4.35

The corresponding points in the steam-consumption curve Fig. 5 are M_1,M_2 and M_3, the subscripts denoting the case.

In determining the economic value of any cycle performed in a prime mover, the mean effective pressure is

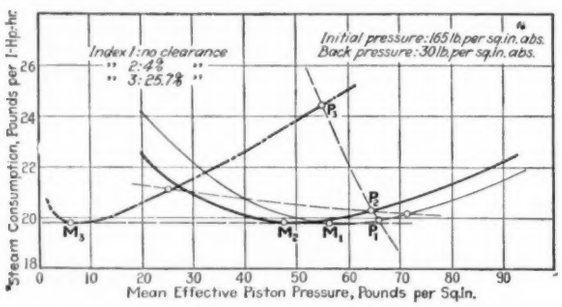


Fig. 6—Steam consumption with 30 lb. at back pressure

an important item. It must be borne in mind that the overall economy of the operation is not only given by the costs of the fuel, but also to a very noticeable extent influenced by the initial cost of the engine, and all understand that the cost of an engine depends on its size and its size for a given duty on the mean effective pressure at which the engine is rated. Another point that must be considered is the friction loss. This loss, being independent, in a wide range, of the mean effective pressure and averaging about 3 lb. per sq.in., would be about 70 per cent for the engine in Case 3 and only about 7 per cent for Case 1. A classical example of this kind is Diesel's first experimental oil engine, in which the Carnot cycle was realized to an astonishingly perfect degree, but which had a mean effective pressure so low that the indicated work was entirely consumed by the friction.

Considering these facts, it will be seen that a cycle that transforms heat in a most perfect way into mechanical (indicated) work will not coincide with the most economical cycle for practical operation. This fact leads to abandonment of complete expansion when determining the normal mean effective pressure and calculating the size of the engine for a desired output. The breaking off of the expansion at terminal pressures above the back pressure means a comparatively small loss in work, but a large gain in mean effective pressure.

In Fig. 2 a terminal pressure of 40 lb. per sq.in. abs. is assumed. For comparing the diagrams in Figs. 1 and 2, attention is called to the fact that the volume scale is five times as large in Fig. 2 as in Fig. 1. In the steam-consumption curves in Fig. 5 the corresponding points N_1, N_2 and N_3 indicate the following values for the mean effective pressure and the steam consumption.

Engine case	1	2	3
Clearance, per cent	0	4	13.35
Mean effective pressure, lb. per sq.in.	85.4	75.5	51.75
Steam consumption, lb. per hp.-hr.	17.0	17.3	18.5

The work balance for diagrams of the three cases 1, 2 and 3, in Fig. 2 is as follows:

	Case 1	Case 2	Case 3
Complete expansion work, ft.-lb. per 1 lb. steam admitted	130,700	130,700	130,700
Areas shown in Fig. 3	ABC_1D_1	ABC_2D_2	ABC_3D_3
Loss due to incomplete expansion of 1 lb. steam admitted, ft.-lb.	13,950	13,950	13,950
Area	$T_1C_1c_1$	$T_1C_1c_1$	$T_1C_1c_1$
Loss due to incomplete expansion of steam inclosed in clearance space, per 1 lb. steam admitted, ft.-lb.	0	2,140	9,850
Areas*	0	$D_2X_2Y_2$	D_3X_3Y
Total loss due to incomplete expansion of working steam. (1 lb. steam admitted plus steam inclosed in clearance) per 1 lb. steam admitted	13,950	16,090	23,800
Areas	$T_1C_1c_1$	$T_2C_2c_2$	$T_3C_3c_3$
Net work, ft.-lb.	116,750	114,610	106,900

* Since the recovery per pound of steam is the same in all cases, the loss due to incomplete expansion must also be the same per pound of steam admitted.

From these values of the net work done by one pound of steam admitted, the given figures of the steam consumption and mean effective pressure are derived.

In explanation of the losses shown in the "work balance," it should be stated that the total loss due to incomplete expansion is increased by the clearance, as the steam inclosed in the clearance space has lost energy because of the pressure drop from T to C. This lost energy is shown in the diagram by the areas $D_2X_2Y_2$ and $D_3X_3Y_3$, as these areas represent the work that is to be expended to recompress the clearance steam from the back pressure to the terminal pressure. The increase of the loss due to incomplete expansion and represented by the areas $D_2X_2Y_2$ and $D_3X_3Y_3$ is to be charged against the clearance. It, therefore, causes not only a reduction of the mean effective pressure, but also an increase of the steam consumption if the engine is not working with complete expansion.

In Fig. 3 an engine of a given displacement with clearances of 0, 4 per cent and 13.35 per cent, was assumed and the comparison of the steam consumption and the mean effective pressure is performed with equal cutoff of 26 per cent. In Fig. 5, O_1, O_2 and O_3 are the corresponding points from which the steam consumption and mean effective pressure reads as follows:

Clearance, per cent	0	4	13.35
M.e.p., lb. per sq.in.	79.4	75.5	65.9
Steam consumption, lb. per hp.-hr.	16.42	17.3	19.8

The "work balance" for the three diagrams 1, 2 and 3 in. Fig. 3 is as follows:

Case	1	2	3
Complete expansion work, ft.-lb. per lb. steam admitted	130,700	130,700	130,700
Loss due to incomplete expansion of 1 lb. of steam admitted, ft.-lb.	10,100	13,950	20,200
Loss due to incomplete expansion of steam inclosed in clearance space, ft.-lb. per lb. steam admitted	0	2,140	10,500
Area	0	$D_2Y_2X_2$	$D_3X_3Y_3$
Total loss due to incomplete expansion of working steam per 1 lb. steam admitted, ft.-lb.	10,100	16,090	30,700
Areas	$T_1C_1c_1$	$T_2C_2c_2$	$T_3C_3c_3$
Net work, ft.-lb. per 1 lb. steam admitted	120,600	114,610	100,000

From these calculations it will be seen that the increase of the clearance space from 4 per cent to 13.35 per cent necessary to adapt the unaflow engine to atmos-

pheric exhaust operation causes a 12.7 per cent decrease of mean effective pressure and a 14.45 per cent increase of steam consumption.

In Fig. 4 the diagrams 1, 2 and 3, areas $ABT_1c^1C_1$, $ABT_2c^1C_2$ and $ABT_3c^1C_3$ are drawn for a back pressure of 30 lb. and the corresponding clearance of 25.7 per cent to cover Case 3. In Fig. 6 the points P_1, P_2 and P_3 correspond to the diagrams, and it can be easily recognized that the disadvantages caused by the additional clearance increase with the back pressure.

As mentioned in the beginning, in practical operation varying back pressure must be taken into consideration. This would make it necessary to provide variable additional clearance spaces for an engine with no exhaust valves, but as this is obviously impossible, to avoid excessive compression pressures the clearance space must be made large enough for the highest back pressure to be expected. In case the back pressure drops, the compression pressure will not reach the boiler pressure and steam must be admitted to help fill up the clearance space. This causes a further considerable loss of work indicated in diagram 4, Fig. 4, by the area AFZ, which must be charged against the clearance.

For the assumption that the engine with 25.7 per cent clearance provided for 30 lb. per sq.in. abs. back pressure is to be operated at 16.5 lb. per sq.in., the steam consumption curve with the point O_4, which corresponds to diagram 4 in Fig. 4, has been drawn in Fig. 6.

The "work balance" for Point O_4 reads as follows:

Complete-expansion work, ft.-lb. 1 lb. steam admitted	130,700
Total loss due to incomplete expansion of working steam, ft.-lb. per lb. steam admitted	28,600
Area	$T_4c\ C_4$
Loss due to filling of clearance space, ft.-lb per lb. steam admitted	7,300
Area	AZF
Total loss, ft.-lb. per 1 lb. steam admitted	35,900
Net work, ft.-lb. per 1 lb. steam admitted	94,800

This net work results in a mean effective pressure of 62.2 lb. per sq.in. and a steam consumption of 20.9 lb. per hp.-hr.

The auxiliary exhaust valves permit an easy adaptation of the unaflow engine to the new back pressure simply by shifting the point at which compression begins. The steam-consumption curve M_2P_2 in Fig. 6 will be replaced by the curve M_2N_2 in Fig. 5. Point N_2 is to be compared with point O_4. From this comparison it will be seen that the clearance space of 25 per cent causes a 17.6 per cent decrease in mean effective pressure and a 20.9 per cent increase in steam consumption over the engine with a normal 4 per cent clearance.

All the foregoing comparisons are based on the theoretical computation of the steam consumption, mean effective pressures and the work per pound of steam admitted, disregarding the losses due to the interchange of heat between the walls and the steam and of the losses due to throttling of the incoming and outgoing steam. Both of these losses will be higher in the actual performance if the engine with additional clearance, as the amount of metal and its surface exposed to the steam in the cylinder undoubtedly is larger when additional clearance space is used. Also the moving forward and backward of the clearance steam has a very undesirable effect on the interchange of heat and besides produces additional throttling losses.

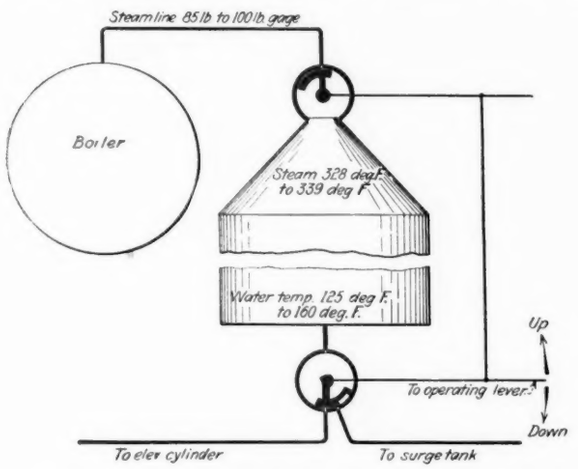
To summarize: The unaflow engine with normal clearance and auxiliary exhaust valves will give a larger output from a given amount of steam at a greater economy under all conditions of back pressure than the unaflow engine with additional clearance space.

Difficulties with Hydro-Steam Elevators

By Warren Hilleary

Hydro-steam elevators, of which there are still a considerable number in use, are not always satisfactory. This type generally consists of a horizontal-cylinder hydraulic engine, or a direct-lift plunger, a vertical tank partly filled with water, a steam line from the boiler plant to the top of the tank, a rotary valve on the steam line at the tank, a similar valve on the bottom of the tank, a pipe connecting the bottom of the tank and its valve to the elevator cylinder, a sprocket chain or wire rope connecting the two valves, and a connection from the car-controlling lever to the valve on the bottom of the tank.

When the car lever is in its central position, the valves at the top and bottom of the tank are both closed as in the figure. When the lever is moved on the "up" position, both the valves are opened simultaneously, the top one admitting steam from the boiler to the space above the water in the tank, the bottom one admitting water from the tank to the elevator cylinder. When the lever is placed on the "down" position, the steam


Steam line 85 lb to 100 lb gage
Boiler
Steam 328 deg F. to 339 deg F.
Water temp. 125 deg F. to 160 deg. F.
Up
To operating lever
Down
To elev. cylinder
To surge tank

Schematic diagram of steam-hydro elevator tank and piping

valve on top of the tank remains closed, the valve on the bottom opens a port between the elevator cylinder and the discharge pipe leading to the surge tank, the port between the surge tank and the cylinder remaining closed.

Unless the steam line to the top of the tank is automatically drained by means of traps, the steam that condenses while the elevator is standing still remains in the pipe; then, when the lever is thrown on the "up" position, the steam from the boilers will not for a fraction of a second be effective in the tank at full pressure, and the car, instead of going up, will start downward until a pressure has been established in the tank that will sustain the weight of the car. Where there is a considerable accumulation of condensate in the steam line and the valve at the top of the tank is opened for an instant and again suddenly closed, there is a possibility of breaking the valve by water hammer, as has occurred a number of times. These dangers, together with the fact that it is practically impossible to maintain the necessary adjustment between the two principal valves, make this type of elevator unsatisfactory.

Pulverized-Fuel Systems—II*

Types of Pulverizers Used in Unit and Multiple Systems, Their Construction and Operation

By A. L. COLE†

MANY of the larger types of pulverizing mills now in general use, in the preparation of coal for burning in pulverized form in the boiler plant, have been used for a number of years in the cement and other industries. The developments during the last few years have been devoted principally to small or unit pulverizers for use in direct firing of boiler furnaces. A number of these mills are in course of development, but are not sufficiently advanced for a description to be included in this article.

The commercial machines used for pulverizing coal come under two general classes, the screen type and air-separation type. The former discharges the coal through a screen in the casing, while the latter has a closed casing and the pulverized coal is removed from the mill by a current of air induced by a fan or exhauster mounted on the mill or adjacent to it. These two classes may be further divided into general types as follows: Hammer, paddle, ring-roll, ball, and tube mills.

Large Capacity Mills Under Development

The capacity of the mills now in general use range from ½ to 10 tons of coal per hour, but with the adoption of pulverized fuel in large central stations, burning several hundreds of tons of coal a day, the need for a larger mill was at once apparent and has resulted in the development of pulverizers having a capacity of from 15 to 25 tons of coal per hour. Where large quantities of coal are used, mills of this size will not only reduce the power consumption and maintenance cost per ton of coal pulverized, but will materially lessen the floor space required for a given output.

The various types of pulverizer embody several principles in grinding; namely, shearing, attrition, crushing by pressure, crushing by impact on anvil, crushing by impact in space. Several of these principles are used simultaneously in the same machine, as will be apparent from the following description of the different types.

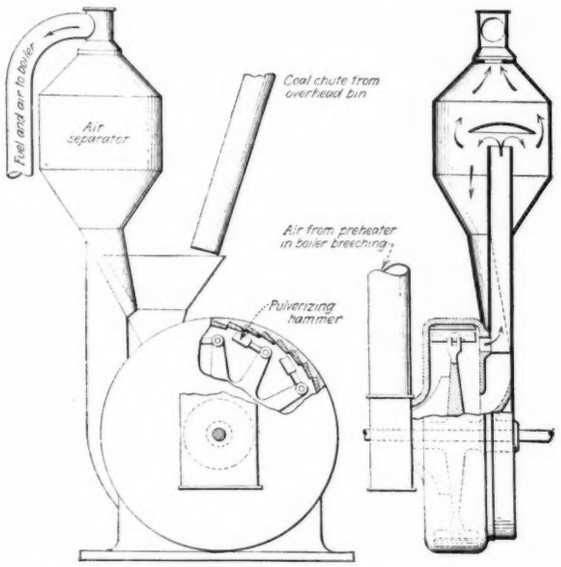
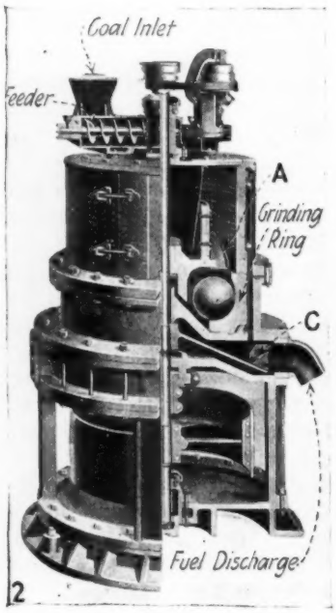
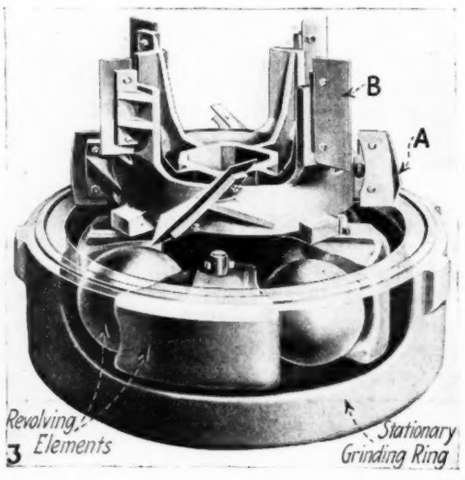

Fuel and air to boiler
Air separator
Coal chute from overhead bin
Air from preheater in boiler breeching
Pulverizing hammer

Fig. 1—Principal details of the Bettington mill

One of the earlier types of pulverizers to be used extensively during the pioneer work in firing boilers with pulverized coal was the Bettington mill, shown in





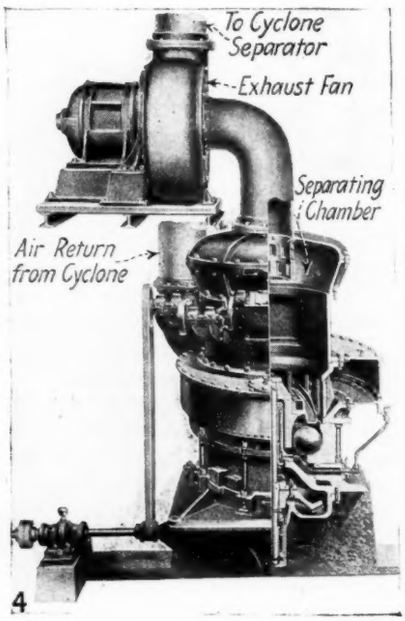
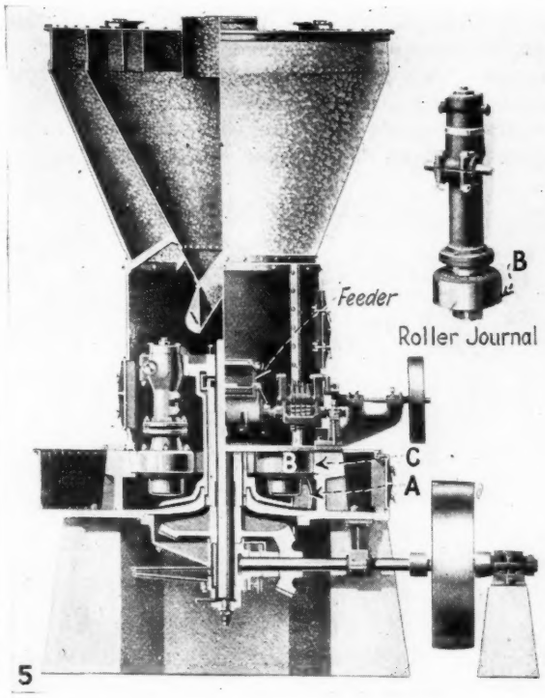
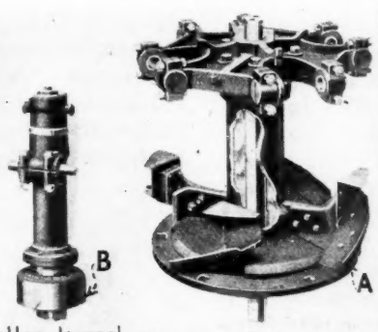


Fig. 2—Fuller-Lehigh screen-type mill Fig. 3—Pulverizing elements and separating fans. Fig. 4—Air-separator-type mill with motor-driven exhauster

*The first article of the series appeared in the June 3 issue.
†Assistant editor of *Power*.

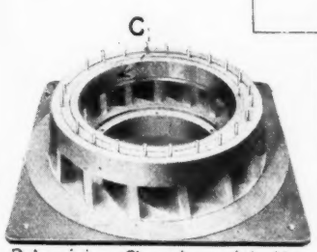


5

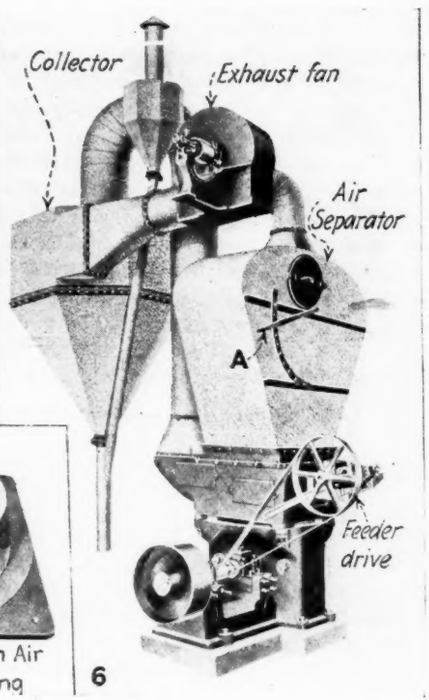


Roller Journal

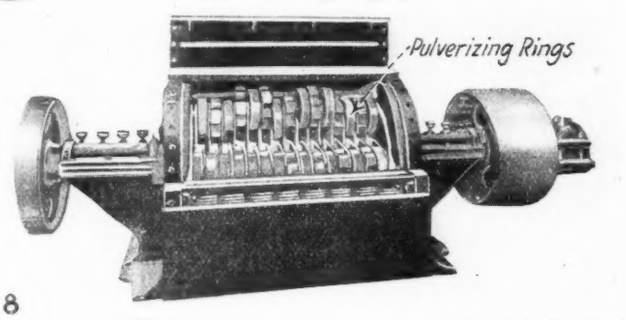
Plow and Roller Spider



Pulverizing Chamber with Air Ports and Grinding Ring

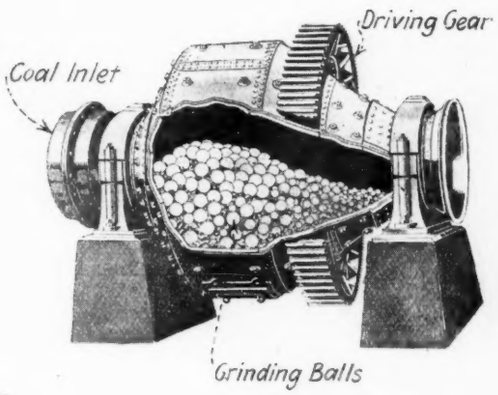


6

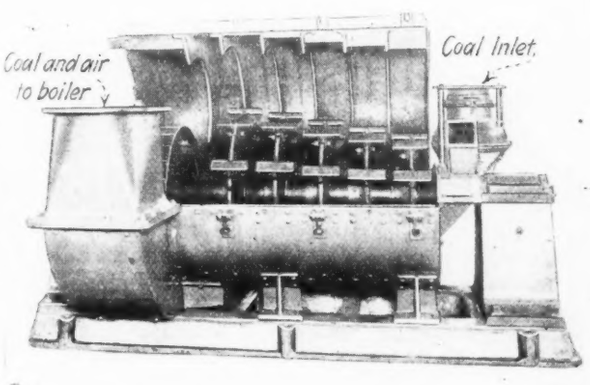


8

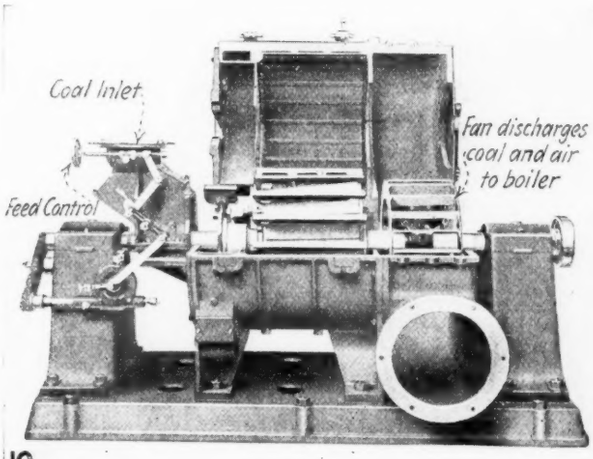
Fig. 5—Raymond mill and pulverizing elements
Fig. 6—Bonnot mill with air separator and collector
Fig. 7—Hardinge conical ball mill
Fig. 8—American rolling-ring pulverizer
Fig. 9—Aero unit-type pulverizer
Fig. 10—Erie City (Seymour patent) unit pulverizer



7



9



10

Fig. 1. This mill was developed by M. Claude Bettington, of Johannesburg, South Africa, and formed a part of a unit system used with a vertical boiler especially designed by him for firing with pulverized coal. The pulverizer is a single-stage paddle mill with hammers pivoted on the ends of rotating arms. The rotating element also serves as a fan and furnishes the draft for the boiler. The whole of the air required for combustion (previously heated by the flue gases) passes through the pulverizer and carries with it the powdered coal into a separator, from which the fine particles are carried over to the burner with the air and the coarse particles fall back again into the mill. The mill operates at a speed of 1,400 r.p.m., and the power required is from 25 to 30 kw.-hr. per ton of coal, including that needed for the air supply.

Screen-Type Pulverizer

One of the chief types of pulverizers in which the separation is effected by means of screens is shown in Fig. 2. The coal to be pulverized is fed to the mill from an overhead bin by a screw or cradle feeder. The screw type of feeder is driven direct from the mill shaft by a three-step cone pulley which permits operative adjustment. If the cradle type of feeder is used, an eccentric and link motion is provided for regulating the feed. As the coal is discharged from the feeder, it falls into the pulverizing zone of the mill. The pulverizing element consists of four unattached steel balls which roll in a stationary horizontal concave-shaped grinding ring. The balls are propelled by the four arms of the pusher or yoke which is keyed directly to the mill shaft.

When the material is reduced to the desired fineness, it is lifted out of the pulverizing zone by the inclined blades of the separating fan *A*, which is mounted on

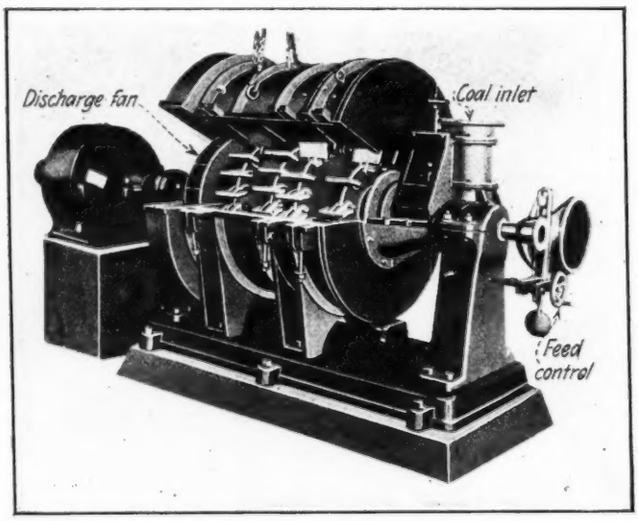


Fig. 11—Fuller unit-type pulverizer

the rotating element just above the balls. These blades discharge the coal in the path of the upper radial blades *B* (see Fig. 3), which throw it against the internal face of the cylindrical screens by centrifugal action. A second fan *C*, directly below the pulverizing zone, causes a light current of air to be drawn through the screen carrying with it the finished product. The coal that is still too coarse to pass the screen falls back into the pulverizing zone for further grinding. A fine and a coarse screen are used, the finer one being on the outside, where it is protected by the inner grid which separates the coarser particles.

This same type of mill equipped with air separation and a horizontal geared drive is illustrated in Fig. 4. This mill has much the same constructional features as the screen type. The feeder is located on the side

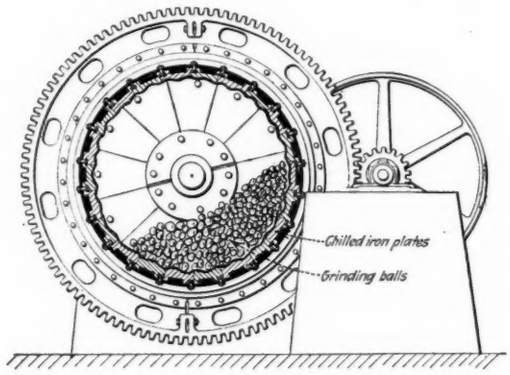


Fig. 12—Typical cross-section of ball and tube mill

of mill and is belt driven from the horizontal driving shaft. The arrangement of the pulverizing element is essentially the same, the principal difference being in the method of removing the finished product from the mill.

As soon as the material is reduced to the required fineness, it is carried away in suspension in a current of air induced by an exhaust fan that is either belted from the horizontal drive shaft or independently driven as shown in Fig. 4. The fan discharges into a cyclone separator where the velocity is reduced sufficiently to allow the solid particles to deposit by gravity. The air from the collector is returned to the mill where it enters just above the grinding zone and is again utilized in removing the finished product from the mill.

Multiple Roller Mill with Air Separation

In the pulverizer shown in Fig. 5, the grinding rolls are suspended by a short horizontal shaft pivoted from a spider that is keyed directly to the mainshaft. The coal enters the grinding chamber through a feeder mounted on the side of the mill. In the grinding chamber the inclined blades *A*, or what are commonly termed plows, throw up the coal between the rollers *B* and grinding ring *C*. The central shaft is rotated by gears, in the base of the pulverizer and carries the rolls around with it. This rotary motion forces the rollers radially outward against the pulverizing ring and provides the force for crushing the coal.

The mill is fitted with single- or double-shell separators according to fineness of product desired. The finished material is removed from the separator by an exhauster located adjacent to the mill and discharged to a collector. The air that lifts the coal enters the mill through a series of tangential openings surrounding the base of the grinding chamber and passes upward around the roller and grinding ring, carrying with it the finished product. The roller and journal, rotary element with spider and plows, and the grinding ring are shown in detail at the right of Fig. 5.

In the mill shown in Fig. 6 the coal is pulverized between four rollers which are free to move radially in

slots in a driver mounted on a horizontal shaft and grinding ring. The inner surface of the latter is concave, which assists in holding the material in the paths of the rolls. This mill differs from the ring-roll mills shown in Figs. 2, 4 and 5 in that the grinding rings stand in a vertical instead of a horizontal position. The sheet-metal separator mounted on the top of the grinding chamber is fitted with two adjustable

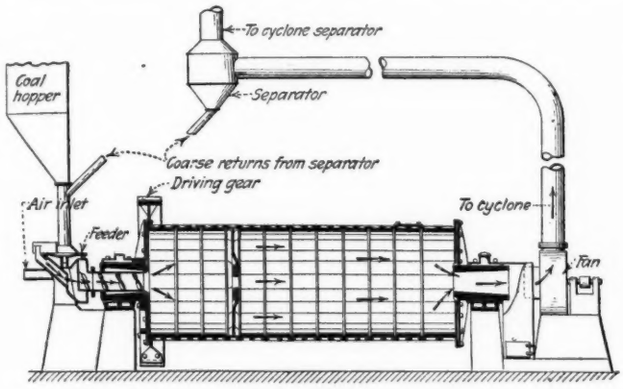


Fig. 13—Typical tube mill, air-separator type

deflectors hinged at the bottom and adjusted by a lever *A* on the outside of the separator. By changing the position of these deflectors, a considerable range of fineness is secured. To obtain a fine product, the deflectors are inclined outward to a position parallel with the side of the separator, while for a coarser product they are set in a vertical position. The velocity of the air current and the position of the deflector determine the degree of fineness.

Ball-and-Tube Mills

In the pulverizer shown in Fig. 7 the forged-steel or cast iron-balls are used as the grinding media. The mill is built with a short cylindrical section in the middle and with conical ends and is supported on hollow trunnions. The feed end is only slightly conical, while the discharge trunnion *B* is at the apex of a long cone. As the drum is rotated, the balls in rolling and dropping grind and crush the material passing through the mill. By virtue of its design or shape of the drum a condition exists in the mill that causes a natural segregation of both grinding media and the material being ground. The coarse coal, on entering at the feed end, is first crushed by the large balls, and as the particles are broken down, they automatically work their way toward the discharge end of the mill, being subjected to a gradually diminishing breaking and crushing effect as they decrease in size. The interior of the drum is lined with chilled iron plates known as Titanite. The plates are in sections and are held in place by wedge-shaped bars and taper-head bolts. In some installations these mills are operated in closed circuit with air separation, most of the oversize being handled and returned mechanically.

Several types of tube mills have been developed in which grinding is accomplished in a manner similar to the mill just described. In these mills the drum is a straight cylinder and in some types is divided into two or more sections in which are different-sized balls. The material, as it is reduced to the required fineness, is removed from the mill by displacement, or air separation. Typical cross-sections of this type of mill are shown in Figs. 12 and 13. The balls that constitute the grinding media usually occupy from 30 to 35 per cent of the mill volume, the material being pulverized occupying the voids between the balls. In operation a slipping and sliding action takes place between the balls, also the bombardment of the cascading balls as the mill rotates, subjects the material to a crushing and grinding action throughout its entire mass.

Mills of the ball-and-tube type are inherently simple to operate and require little attention. The wear on the grinding elements is compensated for by adding at intervals a certain proportion of new balls, along with the material being ground. Mills of this type operate at comparatively slow speeds, the average being around 30 r.p.m.

Unit-Type Pulverizers

Fig. 8 shows the grinding section of a roll-ring pulverizer that forms part of a powdered-coal system operating on the unit principle. The coal is supplied to the mill by an eccentric-driven feeder, hand regulated, or by a motor-driven feeder regulated by maximum and minimum solenoids inserted in the supply circuit to the pulverizer motor.

Overfeeding loads up the pulverizer, causing a flow of current greater than normal so that the maximum solenoid functions and stops the feed; when the load has lightened and the flow of current is less, the minimum solenoid starts the feeder.

The pulverizing elements are steel rings loosely mounted on rods. The holes in the rings are approximately 6 in. in diameter, so that the rings are free to fly out by centrifugal force until their outer edges just clear the stationary casing. The mill operates

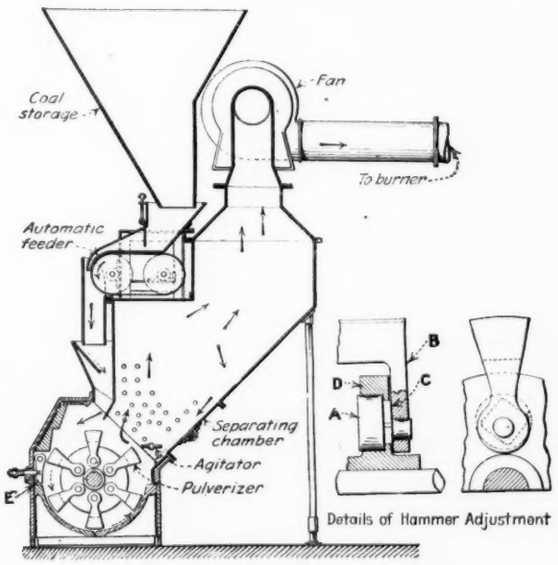


Fig. 14—K-B unit-type pulverizer

with air separation, the finished material being discharged by a fan directly to the burner at the boiler.

With the probable exception of that shown in Fig. 8, the mills described in the foregoing have in general, been adapted to installations of multiple or central coal-preparation plants. Within recent years several types of pulverizers have been developed ranging in capacities from 750 to 4,000 lb. of coal per hour, for installation in plants where the fuel requirements are too small to justify a separate or central preparation plant:

This system of pulverization provides one or more pulverizers for each furnace, depending upon the size and capacity required. These pulverizers receive the raw coal without drying, pulverize it to the required fineness and deliver it to the furnace mixed with the required amount of air for combustion, without the employment of driers, separately driven feeders or separately driven primary air fans.

As the unit pulverizers shown in Figs. 9, 10 and 11 are quite similar, a description of one only will be given. The difference in constructional features will be apparent by referring to the illustrations.

The pulverizer shown in Fig. 10 consists of a rotor with five disks equipped with manganese-steel paddles. The pulverizing is accomplished by the contact of coal in five separate compartments within the mill. The coal in contact with the revolving paddles is traveling at higher velocity than that thrown by centrifugal force toward the periphery of the compartment. It is claimed that this speed differential causes the contact of particle on particle and thus effects the pulverization. There is no contact between the metal pulverizing parts of the mill.

The particles reduced in one chamber to the determined size are carried by air to the succeeding compartment of larger diameter for finer pulverizing, which is accomplished by like action. The pulverized coal, with air regulated at the will of the operator, is ejected from the machine by the fan. By adjusting the openings on the fan inlet, any desired mixture of coal and air is obtained and the flame in the combustion chamber is controlled. By variation in the opening of the air inlet at the coal feed table, a wide range of fineness may be obtained. The power consumption in this type of pulverizer depends on the physical characteristics of the coal, such as fusibility structure and percentage of ash. The average power consumption varies with the kind of coal over a range of from 14 to 22 kw.-hr. per ton.

The pulverizer shown in cross-section in Fig. 14 differs from the unit pulverizer shown in Figs. 9, 10 and 11 in that the pulverizing section is very narrow and the air separation is effected by an independently driven fan mounted on the top of the machine or in any convenient location adjacent to the mill. The coal is fed to the pulverizer by a belt type of feeder driven by an adjustable mechanism and by means of which the amount of feed is regulated to suit the boiler requirements. The pulverizing element consists of six U-shaped swing hammers that revolve at 900 r.p.m.

Coal from the feeder is admitted to the mill through an opening at the top and falls directly into the pulverizing zone, where it is struck by the revolving hammer and driven against the breaker block *E* from which it rebounds again into the path of the hammer and the action is repeated. The particles are finally carried around and discharged by centrifugal force upward to the separating chamber. The air for separation enters the mill through the holes in the casing just above the pulverizing element.

A special feature of this pulverizer is the method used of adjusting the hammers to compensate for the wear. Referring to the detail at the right of Fig. 14 *A* is an eccentric on which the hammer *B* is hung. This pin has a square end *C* which fits into a socket in the rotor plate *D*, providing four adjustments. By turning the pin 90 deg., the hammer is lengthened. When the hammers have been reset, the breaker block *E* is set up by means of adjusting screws until it just clears the hammers. Another feature is the provision made for using a magnetic pulley when desired, at one end of the belt feeder to remove the tramp iron from the coal.

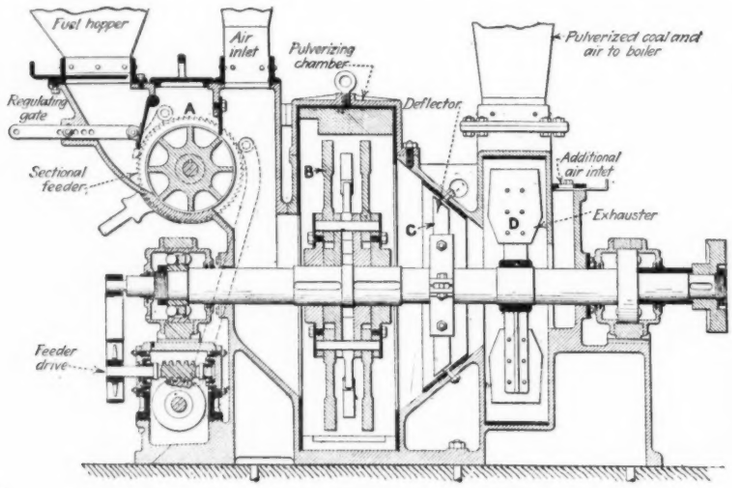


Fig. 51—Longitudinal section of Raymond (Impact) unit type pulverizer

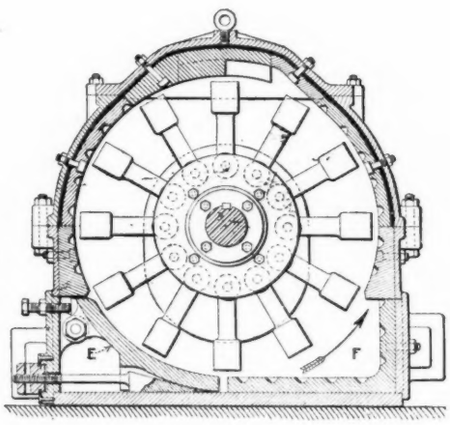


Fig. 16—Cross-section through pulverizing chamber

The machine is designed to handle any coal that will pass through a 2-in. ring, and it can be adjusted to deliver from about 60 to 120 cu.ft. of air per pound of coal.

One of the most recent developments in unit-type pulverizers is the "Impact," shown in Figs. 15 and 16. The machine consists essentially of a feeder *A*, a pulverizing element *B*, a regulating deflector *C* and an exhauster *D*. The coal to be pulverized is fed in regulated quantities by the sectional feeder which is rotated by means of a ratchet wheel and pawl connected by a link to a worm gear, which in turn is driven by a worm and belt from the end of the mainshaft.

The pulverizing element consists of a series of hinged hammers revolving in a chamber lined with hard metal plates having serrated surfaces.

Referring to the cross-section of pulverizing chamber,

it will be seen that a hinged section *E* is incorporated in the chamber lining. This section is adjusted by means of a wedge and screw to bring it nearer or farther away from the hammers and thus take up for wear and vary the fineness to some extent. Directly opposite this section a pocket *F* is provided for taking care of tramp iron or other foreign material that may enter with the coal. This section is readily withdrawn from time to time and the foreign substance removed.

Located about midway in the conical throat between the pulverizing element and the exhauster *D* is a regulating deflector *C*, the function of which is to return the larger particles to the hammers for further grinding.

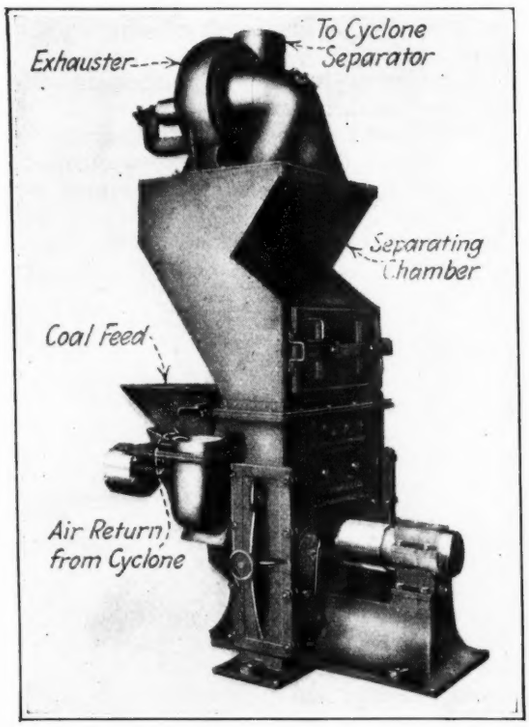


Fig. 17—Stroud air separation pulverizer

As the coal is reduced to the required fineness, it is removed from the pulverizing chamber by a current of air induced by the exhauster *D*, which discharges it mixed with the required amount of air for combustion directly to the boiler furnace.

Necessary Fineness Varies with Kind of Coal

Since the necessary fineness to which the coal must be pulverized depends to a large extent on the nature of the coal and the power required for grinding increases rapidly with the degree of fineness, it would seem desirable to ascertain by experiment in any installation what degree of fineness is necessary for the best over-all results. The dimensions of the openings in standard screens used for this purpose are as follows:

TESTING SCREENS OF WIRE MESH CLOTH

Mesh Openings per Linear Inch	Wire Diameter, Inches	Opening Width, Inches	Openings per Square Inch
100	0.0045	0.0055	10,000
200	0.0021	0.0029	40,000
300	0.0016	0.0017	90,000

Previously, it was considered necessary to pulverize all coals to a fineness of 95 per cent through a 100-mesh and 85 per cent through a 200-mesh in order to obtain good efficiency. This figure still holds good for anthracite coals of low volatile content, but for bituminous coal of high volatile content, a fineness of 65 to 70 per cent through a 200-mesh is now generally considered as satisfactory.

Hints on Hydraulic Elevator Operation

Much of the dissatisfaction experienced with the hydraulic type of elevator, is caused by the pressure on the system being carried much higher than the design of the valve-port openings contemplated. To get greater speed and carrying capacity and to gain time in making starts and stops, the attendants often increase the pressure on the system from 10 to 30 lb. and open the pilot and main valve ports to their fullest extent. This causes the "lever to be too sensitive," making the start too fast, the stop also too fast and abrupt, and the main valve too hard to hold on its central or stop position.

When the pilot and main valves are tampered with, it generally becomes necessary also to tamper with the speed regulating or governing valve in the top of the circulating pipe (on types having this valve). The tampering is commonly done, yet it greatly increases the danger to passengers, increases the repair costs and shortens the life of the entire equipment.

Frequently, when an increase of pressure is apparently necessary, the desired extra speed and starting capacity can be obtained by adding to the water in the surge tank about five pounds of dissolved soft soap for each 1,000 gal. of water in the surge tank. This is not recommended except where the surge and pressure tanks are to be cleaned and painted every three months. The soap effectively lubricates all water-wearing surfaces, and the cost is nominal, even where there is considerable leakage to the drains, but unless the tanks are cleaned and painted every three months, corrosion takes place.

When the water is being discharged from the cylinder of any cylinder type of hydraulic-elevator engine, it travels at a high velocity, sometimes as great as 1,200 ft. per min. When controlling valve is closed to stop the elevator, the tendency of this body of water is to continue in motion, and if there is no opening to the atmosphere between the valve chamber and the open end of the surge line, vacuum may be great enough to pull the main valve off its position, thus causing the car to move, even though the pilot is on the stop position. The partial vacuum formed may draw the column of water in the discharge line back against the controlling valve, causing water hammer. To prevent the vacuum from forming, a vacuum breaker is usually installed as close to the discharge end of the main valve as possible. This is merely a vertical check valve open to the atmosphere. The inspector should raise this valve with his fingers to see that it is in working order. When it is raised, water may rush out, but the valve may be quickly dropped, allowing only a quart or so of water to pass.

Occasionally one hears a reference to turbines abroad operating at 90 per cent Rankine cycle ratio of efficiency. Reliable advices indicate that this is a fact established by test. The machine is believed to resemble a Rateau type, with greater refinements than are utilized in this country.

Spring Meeting of A. S. M. E.

THE spring meeting of the American Society of Mechanical Engineers held in Cleveland, May 26-29 inclusive was especially well attended and the large number of power-plant papers covering such subjects as power in the steel industry, powdered coal, the mercury boiler, vibration in turbine disks and heat transmission proved of wide interest to power engineers. Space does not permit a complete report of these sessions nor of the joint sessions which the Society held with the American Society for Testing Materials and the American Society of Refrigerating Engineers. Some of these papers will be abstracted more fully at a later date

Power Problems of the Steel Industry

THIS important subject occupied a whole session at which several papers were presented and considerable discussion offered.

In a paper on "Power Organization in the Steel Industry," Bryant Bannister and F. M. Van Deventer contended that the complexity of problems encountered in the operation of the power system of a steel works are of greater magnitude than in the average central station and are such as to warrant the organization of a highly qualified power department. For instance, a five-blast-furnace steel plant will require annually about $2,000,000 worth of fuel as compared with $1,500,000 worth of fuel in a central station of 100,000-kw. capacity operating on a 60 per cent load factor. The latter employs only one kind of fuel, whereas the former may have to deal with coal, blast-furnace gas, coke-oven gas, tar, coke breeze and waste heat. Moreover, the high load factor that obtains at steel-works power plants warrants the consideration of all types of supplementary equipment, and a thorough analysis of the conditions so as to incorporate in the system the type and size of equipment that will yield maximum service for minimum capital outlay.

The authors outlined both an engineering and an operating organization with provision for the proper co-ordination between the two. The engineering organization would look after:

1. Power engineering in connection with plant extensions and modifications.

2. The study of existing works conditions for the purpose of determining what improvements should be made.

3. The study of the power system as affected by changes in manufacturing methods.

4. The investigation of new developments in power equipment.

5. The development of power equipment in co-operation with the manufacturer.

It would include a company power engineer, whose office would be in the nature of a clearing house for data and suggestions, a mechanical engineer and an electrical engineer. The operating organization would be headed by a power superintendent who would have the same standing relative to the works manager as other department heads.

"Generation and Utilization of Steam in the Iron and Steel Industry"[1] was the title of the second paper. The author, John A. Hunter, discussed the various types of power equipment employed by several of the larger steel companies. This tabulation showed a preference for vertical and inclined-tube boilers with an average of about 200 lb. pressure, although 300 is used in some cases. Superheaters and economizers have but a limited application and about three-fourths of the plants are equipped with stokers. There has been only one application of the steam turbine to mill drive, although turbines have become popular for generator drive and the unaflow engine is being widely employed for mill drive and for driving the smaller generators.

At present the iron and steel industry is producing power at an average of about 4.3 lb. of coal per b.hp.-hr. although the best practice is 1.4 lb. of coal.

"The Gas Engine in the Steel Industry" was discussed in a paper by A. C. Danks, who referred to the careful records made of the delays encountered during the early years of gas-engine operation in the steel mills and the

[1] A more detailed abstract of this paper appeared in the June 3 issue of *Power*.

Members of the American Society of Mechanical Engineers

causes for these delays. The results of this study are presented in Table I for a number of plants that for obvious reasons have been designated by letters. These records were all made in the same year, and while there may be some question as to the items "Due" and "Not Due" to engines, the total percentage of time in operation for a year of 8,760 hours is interesting, and it will be noticed that with very few exceptions the delays were longer on the higher-speed electric engines.

TABLE I—ANALYSIS OF DELAYS IN VARIOUS PLANTS

Plants	A*	B	C	D	E	F*	G*	H	I	J
Hours operated	6,375	1,523	3,695	1,407	4,592	7,876	7,806	5,685	3,982	8,137
Hours lost:										
Not due to engine	1,683	6,689	4,080	6,550	4,363	318	381	246	831	476
Due to engine	702	492	627	804	5	566	573	2,075	323	147
Per cent of time in operation	72.8	17.3	42.0	16.1	52.5	89.6	89.0	70.2	77.8	92.7

*Blowing units; all others are electric engines.

This naturally led to a study of just what the delays were traceable to, and while local influences were in some cases found responsible, the greater part was traceable to piston troubles.

The pistons were redesigned and continued in operation for many years without cracking, although a few had to be discarded owing to the width of the ring grooves reaching a prohibitive figure.

When originally installed, the gas engine for this service was provided with water-cooled exhaust valves and piston-rod packing and arrangements were even made to water-cool the inlet valves should it be necessary. This involved endless complication both in construction and maintenance, as water leaks were seemingly always present. The first attempts made to run without water either on the rod packing or exhaust valves were not until these trials had been patiently borne for a year or two.

This led to an entire redesign of these various parts, allowing of much more simple construction and consequently reduced the operating troubles materially.

Operators on the Great Lakes with clean water can have very little realization of the troubles resulting both directly and indirectly from the cooling-water supply that many of the inland plants are obliged to use.

This is particularly true of the Pittsburgh district, where much of the water supply comes from the Monongahela River and at certain seasons of the year carries a sulphurous acid content as high as 8 grains per gallon. When the gas engine was first being introduced in that district, the provisions for treating the water supply were primitive and it was not unusual to have pipe work last only a few weeks at certain seasons of the year. This eventually led to the use of brass pipe for all water-cooling service.

Had the trouble stopped there the results would not have been so bad, but the author remembers one instance where an entire set of piston rods were completely destroyed in less than a year by being eaten away on the inside so that their strength was reduced to the danger point.

It was noticeable that the attack on cast iron and cast steel, on account of their scale, was much less than on the finished steel on the rods, and as nearly all piston rods were then being drilled for side water connections, it became a serious and important matter to protect them. Many rods were cracked owing to weakened sections at these points, and it became necessary to inspect all rods closely for indications of cracks. Considerable difference of opinion existed as to the possible wall thickness of metal that could be tolerated and still leave a sufficiently cool rod surface for safe operation.

This led to a construction by which the water connections were taken from the ends rather than the sides of the rod, and this eliminated the danger of cracks that formerly occurred where these holes were drilled through the rods. The construction consisted in lining the rod entirely with bronze or other acid-resisting material. Where the water passed through the rod under the piston bore, the holes were lined with tin. Bronze distributing blocks were used at the center of the rod, and standard brass pipe for lining the bore, with suitable bronze water fittings on either end for the entering and leaving water.

This particular type of water service to the piston involves the telescoping straight-line sliding plunger. While some types of engine then used and still do use the swinging joint, at the higher speeds this construction is not as desirable as the straight-line telescope.

When the gas engine was being introduced into the steel plants between the years 1907 and 1915, coal could be bought at many of the plants at remarkably low figures, in some cases as low as $1.50 per ton (de-

and guests during their visit to Nela Park, May 26

livered). This, of course, varied with geographic location.

Plants in those localities having the lower price of fuel had a much harder time making a showing from a standpoint of cost per unit production than those with the higher fuel costs. This was indirectly shown in the cost of coke used on the blast furnace and the consequent value of the byproduct blast-furnace gas that the engines were using, as for comparative purposes this must all be reduced to equivalent value of coal at prevailing prices at the particular plant in question.

At that time, also, there were but few plants where the amount of gas that could be saved by the use of gas engines over the other types of prime movers was an important factor, although this condition is becoming more and more evident as the demand for power increases above that actually required at the blast furnaces.

Roughly speaking, gas engines require 125 cu.ft. of blast-furnace gas per indicated horsepower hour, while 600 cu.ft. are required per boiler horsepower-hour. The actual number of B.t.u. per 1,000 cu.ft. of air blast delivered when comparing a number of plants were as follows, conditions of pressure being the same in both cases:

Steam	Gas
34,900 to 87,000	9,500 to 14,410
39,100 to 88,000	11,180 to 16,100

This shows an advantage for the gas engine that is plainly seen when translated into tons of coal. The gas engine is also able to show an advantage when compared with other types of prime movers in the cost of generating current, mainly through the item of fuel. This is forcibly brought out in the comparison presented in Table II, showing the cost of generating electric current in one steel plant by the three common types of prime movers—steam turbines, gas engines and reciprocating steam engines.

From these tables it will be evident that the gas engine has a place in the steel industry that will increase in importance as the cost of fuel advances, thus automatically increasing the values of blast-furnace gas; for, unlike the byproduct gas of the coke oven, it is limited in its range of application to hot-blast stoves, boilers and gas engines. There is no reason why, in plants where this gas supply is in excess of the needs of the stoves and boilers, the surplus should not be used for the generation of electric power for sale to the public-service companies and at a figure much below that for which they can make it with any of the existing steam equipment at the prevailing price of coal.

TABLE II—COST OF GENERATING POWER IN DOLLARS PER 1,000 KW-.HR.

	Steam Engine	Turbine	Gas Engine
Producing labor	$1.0850	$0.6783	$1.5611
Repairs and maintenance	1.4595	0.4024	2.2363
Miscellaneous supply	0.2624	0.1057	0.3295
Steam or gas	8.9788	6.3825	2.3241
Water	2.5206	0.8875	0.2981
Incidentals	0.1509	0.0236	0.2550
Total cost of production	$14.4572	$8.4800	$7.0041

Discussion of Messers. Bannister and Van Deventer's paper emphasized that the savings from such a centralized power department must justify its expense. Without it, however, the individual power engineer is prone to rely too much upon the equipment salesman. It was pointed out that the organization as outlined is not unlike that employed by many central stations, but to be of greatest value it must enlist the interest of both the management, especially of the local units, and of the employees. With two hundred million dollars as the estimated yearly cost of power in the steel industry, big savings are possible.

Discussion

Speaking from the central-station viewpoint, L. W. Heller, of the Duquesne Light Co., urged that the steel men concern themselves chiefly with the application of power leaving its generation to the central-station specialist. He believed there was room for closer cooperation between the central-station and steel-plant engineers than had existed in the past, especially with a view to utilization of all the waste heat and the purchase of supplementary power.

In discussing Mr. Hunter's paper, Ernest Price advocated the use of higher steam pressures, not less than 300 lb. and 200 deg. superheat, steam turbines with stage bleeding and motor-driven auxiliaries, greater use of surface condensers and consideration of powdered coal and air preheaters.

Professor Trinks was of the opinion that it pays to install unaflow engines in new plants, especially where the units are below 6,000 or 7,000 kw. He cited cases where replacement by engines of the unaflow type had saved the cost of the engine in twelve months.

G. R. McDermott took exception to Mr. Hunter's reference to replacement of gas engines by steam turbines and cited the recent installation of large gas engines at the Illinois Steel Co.[2] He pointed out that coke-oven gas is used largely for heating whereas the blast furnace gas of lower calorific value is employed for power. The latter, however, is also used in combination with producer gas for reheating in open-hearth furnaces. Waste heat should be utilized in waste-heat boilers and to replace the more valuable coke-oven gas which can be sold profitably.

Pulverized Coal Proves Live Topic

A PAPER by W. H. Aldrich described the pulverized-fuel installation under four 30,600-sq.ft. Stirling boilers at the Lake Shore Plant of the Cleveland Electric Illuminating Co. The boilers are equipped with economizers, and each is served by sixteen burners, eight on a side. These are pointed downward and at the discharge end are flat in shape with an opening about 14 in. long by $\frac{7}{8}$ in. wide. It has been found that this form of nozzle exposes a much larger surface for mixing with additional air, and for absorbing radiation from the flame than does a solid stream from a round burner. The air supplied to the feeders is preheated to about 100 deg. by being drawn through the bottom of the boiler setting before passing through the fan. Water screens are provided, each screen consisting of forty-two 4-in. boiler tubes spaced 12 in. apart and inclined downward toward the center of the furnace at an angle of 8 deg. from the horizontal.

The furnaces average about 25 ft. wide by 32 ft. across the combustion chamber and are 52 ft. high with a total volume of about 29,000 cu.ft., giving a ratio of furnace volume to heating surface of 0.95.

The boiler settings are built with hollow walls up to the arches or about halfway up the settings. Most

[2]For a description of this installation see *Power*, April 8, 1924.

of the air for combustion is admitted through spring-balanced dampers at the sides of the setting and passes through the hollow walls to the front, where it enters the furnace through numerous 9-in. square openings in the wall under the arch. This hollow wall serves the double purpose of supplying preheated air to the furnace and helping to cool the walls of the combustion chamber. The coal burned averages about 12,500 B.t.u. per lb., 5 per cent moisture, 32 per cent volatile, 54 per cent fixed carbon, 15 per cent ash and 3 per cent sulphur. Owing to the comparatively low moisture content it was decided not to install driers, although provision has been made so that they could be installed later if necessary.

Coal in the form of slack is brought into the boiler house by a conveyor belt and is distributed into bunkers at the top of the building. It flows by gravity through 12-in. galvanized iron pipes to the pulverizing mills in the basement. There are twelve of these 6-ton mills, three to a boiler. The coal is ground to such a fineness that 70 per cent will pass through a 200-mesh sieve and 90 per cent through a 100-mesh. From the mills the pulverized coal is conveyed to the coal bunker through large pipes by air blast from an exhauster fan working under about a 10-in. pressure. This exhauster pipe carries the coal to the top of the building, where it passes through a cyclone separator from which it is fed by gravity directly to the bunkers on one side of the boilers or to a screw conveyor system which supplies the pulverized-coal burners on the other side of the boilers.

The only test so far made was one of 19½ hours on one of the boilers at 150 per cent rating, which showed an efficiency of 83.71 per cent for the boiler and 90.71 per cent combined efficiency on boiler and economizers. Under normal operation the combustible in the ash runs about 0.2 per cent. Acceptance tests of the units are now under way.

Discussion

The discussion of Mr. Aldrich's paper centered around the necessity for drying the coal. R. D. DeWolf, of the Rochester Gas & Electric Corp., stated that the experience of his company had indicated no necessity for drying where the moisture is under 4 or 5 per cent, although provision had been made for the installation of driers should they be deemed necessary in the future. A similar view was expressed by J. B. Johnson, of the United Verde Copper Co. in Arizona, who stated that in that locality the coal is so dry that trouble is experienced from its flooding through the feed screws. He believed that this trouble was likely to occur unless the powdered coal contained from 4 to 5 per cent moisture.

On the other hand, H. G. Barnhurst, of the Fuller Engineering Co., stated that his long experience with powdered fuel had indicated that drying is essential in order to obtain the most satisfactory operation all the year round. While it is true that coal containing 7 per cent moisture is being successfully handled without drying at Milwaukee, a considerable percentage is inherent moisture and not surface moisture. He believed the best results are obtained when surface or free moisture is below 2 per cent and better efficiencies can be obtained by drying the coal before it reaches the finished state. He observed further that the flat or fan type furnace, as used at Cleveland, permits rapid heat penetration and prompt ignition. While the vertical method of firing permits burning a wide range of coals, the horizontal, although limited to fairly high volatile coals, permits a higher combustion rate per cubic foot of furnace volume. Slag has not proved the source of trouble that was early anticipated, and with properly designed furnaces he did not consider water screens necessary for slag prevention. As additional heating surfaces, however, they are useful for recovering heat that would otherwise be lost in ash and radiation.

C. G. Spencer, of McClellan & Junkersfeld, engineers on the Cleveland installation, summarized the following advantages to be gained by a low and uniform moisture content in the coal entering the mills:

(a) Increased boiler efficiency due to less coal being required to evaporate and superheat this moisture into steam which is lost with the flue gases.

(b) Greater mill capacity; it being not unusual to observe a 25 per cent reduction in mill capacity due to an increase of from 2 to 4 per cent in moisture.

(c) A reduction in mill capacity due to moisture is accompanied by an increase in the kilowatt-hours per ton for milling.

Watching the games at Nela Park
Left to right: J. V. V. Colwell, Warren France, President Low and James Partington

(d) Lack of uniformity in dryness has been observed to require a 30 per cent change in feeder speed to maintain a constant evaporation, other conditions remaining the same.

(e) The tendency to arch in bins is reduced as the moisture content is reduced.

(f) Low moisture content reduces the tendency in cold weather for condensation to collect and form a paste throughout the milling, conveying and storage system.

(g) Improved furnace conditions due to more constant rate of coal feed and improved combustion because less heat is absorbed at the point where it is most needed by the evaporation of excess moisture.

With boilers and prime movers of large capacity there has been need for pulverizing mills of greater capacity. A 15-ton mill has recently been put in service in Cahokia, and a 20-ton mill will be installed this summer. The input including air separation and feeder motors will be 13½ kw.-hr. per ton.

Speaking with reference to the temperature in the driers, G. Keeth of the same company, stated that the waste-heat driers at Cahokia were originally started off

at 250 deg., but are now operated at 450 deg. If the coal is kept moving, he believed no trouble need be feared from fires.

Touching upon the subject of slag formation R. D. DeWolf stated further that practice at Rochester was to let the slag build up to a certain thickness and remain on the walls where it will serve as a protection for the walls against erosion from licking of the flames.

Emmet Mercury-Vapor Process

W L. R. EMMET related some of his early work in developing the Mercury Vapor Boiler and Turbine and described in detail the present 1,800-kw. installation at the Dutch Point Station of the Hartford Electric Light Co. This installation was described in *Power*, Dec. 4, 1923, and will not be repeated here. However, for those unfamiliar with the process it may be stated briefly that the mercury is vaporized in an oil-fired boiler, at a pressure of 35 lb. and 812 deg., and after passing through the turbine, is condensed to 29 in. vacuum and 414 deg. The mercury condenser forms the steam boiler in which steam is generated at 200 lb. and 388 deg. The products of combustion after leaving the mercury boiler pass consecutively through a mercury liquid heater, or economizer, a steam superheater and a feed-water heater, thence to the stack.

According to the author the most difficult part of the process is the boiler. While mercury is a good conductor it does not wet steel and considerable temperature difference is required to deliver heat to it at a high rate. Moreover, successful mercury boilers are dependent upon a rapid circulation of the liquid and a considerable difference of pressure between the top and the bottom. While mercury does not oxidize very rapidly when exposed to air even at high temperatures, still a small degree of oxidation renders the metal adhesive and makes it difficult to separate finely divided foreign matter, and stoppages are likely to result. For this reason all the joints in the installation are welded for the double purpose of preventing the escape of mercury and to prevent air leaking into the system, and when the system is shut down it is filled with illuminating gas to protect it against oxygen.

Condensing conditions with mercury are especially good. The liquid does not wet the surface, and the falling drops tend to move the vapor and to give added condensing surface. At Hartford as high as 770 B.t.u. heat transfer per degree temperature difference per square foot per hour has been obtained.

With reference to mercury poisoning Mr. Emmet said that during his ten years of experimentation there had developed no case of mercury poisoning, although on several occasions men had come in contact with mercury vapor in hot places and in one or two cases had become temporarily ill as a result. Every precaution had been taken, however, to guard against such occurrence.

Mr. Emmet was of the opinion that with a more extended application of the mercury vapor process the large deposits of low-grade mercury ore in Alaska, South America, New Zealand and elsewhere could be depended upon to provide an adequate supply at a fair price. At $2 per pound and six pounds of mercury per kilowatt capacity this would mean an initial cost of only $12 per kilowatt, which is relatively small compared with the total unit cost of the average steam plant.

As soon as certain boiler experiments now in progress are satisfactorily completed, it is proposed to install a new boiler of a different type at the Hartford plant. This will be adapted for a pressure of 70 lb. gage, or double that of the present boiler. A three-stage turbine will be used in place of the present one-stage turbine. Mr. Emmet predicted that with such an arrangement and with bleeding the steam turbine to heat the feed water, it would be possible to operate on a base load of about 10,000 B.t.u. per kilowatt-hour.

In an appendix to the paper curves and tables were given showing the properties of mercury vapor. These had been compiled by Mr. Emmet's assistant, L. A. Sheldon.

Discussion

Two written discussions were submitted, one by Prof. L. H. Marks, who questioned the accuracy of some of the figures in the tables showing the properties of mercury vapor, and the other by Joseph Pope, of Stone & Webster, who acted as engineers on the Hartford installation. Mr. Pope submitted the following figures on a recent test of this boiler:

Fuel oil burned per hour	2,046 Lb.
Net electricity generated by mercury turbo-generator	1,258 Kw.-Hr.
Weight of steam made per hour	24,750 Lb.
Heat value of oil as fired	18,534 B.t.u.
Temperature water fed to economizer	197 Deg. F.
Gage pressure of steam delivered	188 Lb.
Superheat of steam delivered	49 Deg. F.
Weight of oil fired per net kw.-hr. generated by mercury T-G only	1.63 Lb.
Weight of steam delivered per pound of oil fired	12.1 Lb.

He presented further tentative figures to show what would be the effect of combining mercury equipment such as that at Hartford with an existing steam plant of 9,600 kw. capacity, 57,850,000 kw.-hr. annual output, 70 per cent load factor and 26,451 B.t.u. per kw.-hr. these figures being matters of actual record.

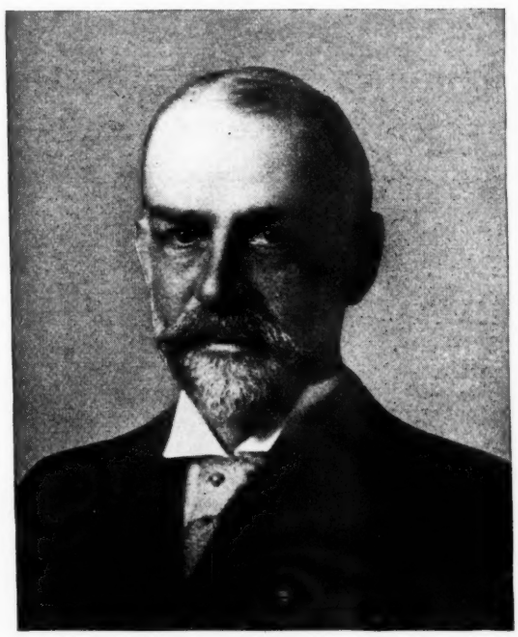
Four mercury units combined with existing steam plant	
Peak load	9,600 Kw.
Estimated output by mercury	30,050,000 Kw.-hr.
Estimated output by steam	27,800,000 Kw.-hr.
Total output	57,850,000 Kw.-hr.
Estimated B.t.u. per kw.-hr.	19,020
Saving in fuel over steam plant	28 per cent

In answer to several questions from the floor, Mr. Emmet mentioned that at Hartford it is possible to determine the level of the mercury at all times by float gages and therefore any considerable leakage could be immediately detected. Moreover, by means of a sensitive paper that has been developed any mercury vapor present in the flue gases can also be detected. With reference to overload under present conditions it is necessary to design the installation on a full-load basis. However, by calorizing the boiler tubes, which may be done in the next installation, it will be possible to force the boiler without overheating. All things considered, however, it is best to use the mercury boiler as a base-load proposition.

Answering a question as to whether other substances might not be used for the binary system Mr. Emmet said that a number had been investigated, but that they would not stand the high heat delivery as well as mercury, most of them being unstable at high temperatures. Sulphur, while it does not change its composition, is viscous at condensing temperature and in this state is a poor heat conductor. Moreover, it will attack iron.

Vibration in Steam Turbine Disks

A VALUABLE contribution to the literature of steam-turbine design was given by Wilfred Campbell, of the General Electric Co., in a paper on "The Protection of Steam Turbine Disk Wheels from Axial Vibration." This paper described the results of an exhaustive investigation which that company made into the various forms of vibration and waves that may be set up in steam-turbine disks, the study having been initiated in consequence of a series of turbine failures



Prof. W. L. Durand
Choice of Nominating Committee for President During 1925

extending over a period of several years subsequent to the war. The rapid increase in turbine capacity that took place at that time was in a large degree accomplished by the use of the larger diameters introduced to give greater bucket speed and by the use of longer buckets. Mechanical possibilities were pushed to the limit from the standpoint of structural strength, and, it soon became evident that most of these failures were due to vibration resulting in fatigue.

Tests were first made of india rubber wheels and then steel disks with which the fluttering action when rotating at high speed was established. Later, by means of sand on stationary wheels placed horizontally and vibrated mechanically, frequencies were determined at which 4, 6, 8, 10 and 12 node vibration would be set up. The higher the number of nodes the higher the frequency of vibration.

Where the natural vibration frequencies of those wheels were determined, the effect of rotating at high speed was studied and it was found to be influenced by the stiffness of the vibrating body and by its mass. The stiffer the wheel or disk the faster it would vibrate, and the greater the mass the slower the vibrations. Increased speed and consequently increased centrifugal force tended to increase the stiffness.

The presence of both stationary and traveling waves was established. It was found that the type of vibration responsible for nearly all the serious failures consisted of a train of backward traveling waves whose backward speed in the wheel exactly equalled the forward speed of rotation of the wheel, resulting in waves stationary in space. The particular speeds of the turbine disk at which this condition would be brought about are characterized as the critical speeds.

A probable cause of stationary waves was found to be a spot or spots of extra pressure, not necessarily more than a few pounds, such as might result from irregularity in the nozzles.

Causes of Vibration Determined

The two general causes of wheel vibration were found to be (a) the feathering action of the steam on the buckets and (b) pulsating forces which may cause various resonant responses of the wheel. The first type of vibration is eliminated by the use of disks of sufficient thickness so that the energy dissipation during vibration is too great to permit a building up of such a vibration. The second type of vibration is eliminated by building the disks so that resonant frequencies are removed so far from disturbing frequencies in the turbine that vibrations do not occur.

In making these investigations the wheels to be tested or duplicates of those that had failed were placed in a specially constructed housing and by means of a stationary magnet opposite the wheel rim and another magnet on the rotating disk, oscillograph records of the wave progression were obtained.

The company has developed a portable compressed-air-driven vibrator for determining the standing frequencies of wheels in service. Out of 4,399 wheels for turbines of over 5,000 kw. installed before March 1, 1924, 3,596 have been tested standing, 320 rotated in the wheel-testing machine, 405 tested in the wheel-testing machine, 1,683 tested in the customers' plants, 497 wheels replaced to avoid possible trouble and 212 have been tuned for vibration.

Centrifugal Fans for Electrical Machinery

The ordinary commercial centrifugal fan is provided with a stationary collecting device, generally a volute which usually improves the performance materially. In fans used in cooling electrical machinery, however, such collecting devices cannot be readily applied, and the revolving impeller therefore forms the sole means for developing the pressure needed to drive the air through the vent ducts.

In a paper on "The Performance of Centrifugal Fans for Electrical Machinery," Carl J. Fechheimer, of the Westinghouse Electrical & Manufacturing Co., gave results of an extended series of tests recently made to determine the performance of centrifugal fans without collecting devices and to obtain sufficient data to enable designers to select types of fans intelligently and to predict their performance. Tests showed that the backward curved vanes are most efficient.

Research in Heat Transmission

AT THE joint session with the American Society of Refrigerating Engineers, a paper on "Research in Heat Transmission," was presented by Dr. Edgar Buckingham, physicist, United States Bureau of Standards, in which the following points were brought out:

Knowledge of heat transfer can be applied not only to such apparatus as evaporators, surface condensers, boilers, etc., in which the object is to attain the maximum heat transfer, but also to insulators ranging from vacuum jackets and granulated cork for low-temperature work, to firebrick and similar refractories at the other end of the scale.

For a given temperature difference the amount of heat passing through a body depends not only upon its thermal conductivity, but also upon the difficulty with which the heat gets into or out of the surfaces from or to the fluids in contact with them. Of these two effects the conductivity of the material is by far the best understood and easiest to deal with.

The transmission of heat between solids and fluids, on the other hand, is extremely complicated. As a result, heat-transfer problems naturally tend to divide themselves into two groups, according to the relative importance of the conductivity and surface effects.

Those concerned mainly with conductivity form a group that can be handled without much difficulty. A good example is found in pipe covering, where the temperature drop from the pipe to the inner surface of the insulation, and from the outer surface of the insulation to the surrounding air, is small in comparison with that through the material. In this case the uncertainties in our knowledge of the surface resistances are made relatively unimportant, while the thermal conductivity of the material, which is here the main thing, can be determined with reasonable reliability in any physical laboratory.

The opposite is true of an ordinary cast-iron steam radiator. Almost the whole of the temperature drop, from the steam inside to the air outside, occurs at two surfaces, mainly at the outer surface, for the conductivity of cast iron is high enough that only a small temperature drop is needed to drive the heat through the iron as fast as it can get away from the outside. If the radiator were replaced by an exactly similar one made of copper, the resistance of the metal and the temperature drop in it would be reduced to about one-sixth, but the temperature drop is already so small that the extra five-sixths thus made available for driving the heat out into the surrounding air would be of very little importance.

Similar remarks might be made about oil coolers, boiler tubes and most types of heat-transfer apparatus in which the heat flows perpendicularly through rather thin metallic walls.

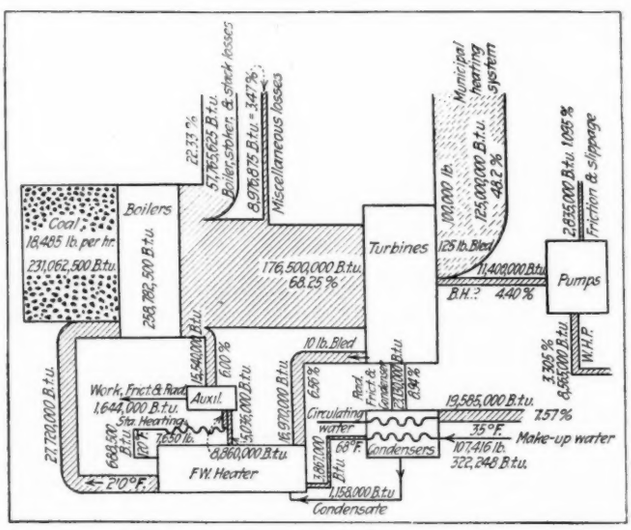
The really important and difficult problems of heat transmission are those dealing with the manner in which heat may get away from a hot surface to a colder space outside, or into a cold surface from a hotter space; namely, by radiation and by convection.

Radiation, varying about as the cube of the absolute temperature, is of the utmost importance in a boiler furnace for example, but is quite negligible in problems of refrigeration engineering. In general, though by no means always, convection is technically more important than radiation. By convection is meant the transportation of heat by motion of the body in which the heat is contained. In the technical application this moving body is nearly always a fluid.

What is demanded of research in technical physics, as distinguished from the very limited experimental investigations which we call tests, is general information that can be used by designers who have to tackle entirely new problems. Small variations from current practice, where test results are already available, can usually be predicted sufficiently well by a combination of common sense and guesswork. But in a large variation, or in an entirely new sort of problem, there is danger of serious mistakes in design unless we have some more general principles to go by and numerical data of a more fundamental nature and more physical significance than are usually obtainable from ordinary performance tests.

Fairmount Pumping Station and Heating Plant

BECAUSE of its local associations and as representing the solution of a nice problem in heat balance, the paper on the New Fairmount Pumping Station of the Cleveland Water Works, by L. A. Quayle, chief



Heat diagram for winter months

engineer of the Water Department, proved of special interest. This plant, which is now nearing completion, is a high-pressure repumping station employing multistage centrifugal pumps driven through reduction gears by bleeder turbines which bleed at 125 lb. pressure to the municipal district heating system which supplies over 300,000 sq.ft. of radiation in residences and business blocks for a distance of two miles. During the summer months they run straight condensing excepting the steam bled at 10 lb. for feed-water heating.

There are eight pumping units in all, one of 50 million, two of 75 million and five of 20 million gallons capacity. The turbines are supplied with steam at 320 lb. and 150 deg. superheat by four 10,000 sq.ft. stoker-fired Stirling boilers. An unusual feature of the installation is that the boiler-room auxiliaries are driven by water turbines having three separate sources of supply thus insuring positive and independent drive.

The chart herewith represents the heat distribution during winter months when steam is being bled to the heating system. For the same pumpage and the same steam heating demand this arrangement represents a saving of more than 2,000 lb. of coal per hour over that of running straight condensing and supplying live steam direct to the heating system. A more complete description of this plant will appear in a later issue.

Industrial Preparedness Explained

A FEATURE session of the Spring Meeting was that on Industrial Preparedness, at which the chief speakers were Col. Dwight F. Davis, Assistant Secretary of War, Bernard M. Baruch, formerly head of the War Industries Board during the war, and Maj. Gen. C. C. Williams, Chief of Ordnance. Colonel Davis outlined what has been done and is being done by the War Department under the National Defense Act to prepare the country in converting peace-time industries to war uses in the event of war. The magnitude of this task is appreciated when it is considered that about thirty thousand articles involving over seven hundred thousand parts are required to put soldiers into the field. Under the present system of organization, the speaker believed that we could convert more than twelve thousand of the country's industrial plants from peace production to war work for manufacture of these articles within a period of twenty-four hours.

Mr. Baruch's address, which was read by former Assistant Secretary of War Benedict Crowell, reviewed briefly the fruits of unpreparedness during the World War and recommended that legislation be put into effect that would give power to the President in case of war that would immediately mobilize the resources of the Nation. This would mean the mobilization of men, money, materials and manufacturing; the fixing of all prices and the regulation and distribution of production. Prices of materials and commodities would be declared fixed as of a certain date and the money would be mobilized by fixing a price at which it could be used. This would tend to prevent a rise in prices and competitive bidding for labor.

Major-General Williams told of the improvements which the Ordnance Department is making with equipment and ordnance material and spoke briefly on the subject of Ordnance.

Excursions Well Attended

Among the plants visited during the convention were the Lake Shore Plant of the Cleveland Electric Illuminating Co., the Fairmont Pumping Station of the city water works, the National Tube Company's plant at Loraine, an inspection trip through the rubber manufacturing plants at Akron, after which a joint session was held with the local Section A.S.M.E. Monday afternoon and evening was spent at Nela Park, the research laboratories of the General Electric Co., where the various departments were inspected and a supper provided followed by entertainment in the evening.

Report of Nominating Committee

The nominating committee reported as follows: For president, Dr. W. F. Durand, of Leland Stanford University; for vice-presidents, R. W. Angus, Toronto, S. F. Jeter, Hartford, Conn., T. L. Wilkinson, Davenport, Ia. Managers, J. H. Lawrence, New York City; E. A. Muller, Cincinnati, Ohio; Paul Wright, Birmingham, Ala. Treasurer, W. H. Wiley, New York. Delegates to American Engineering Council, W. F. Durand, F. R. Low, Ira Dye, W. S. Finley, D. E. Foster, W. P. Hunt, I. E. Moultrop, E. N. Trump, and W. W. Varney.

On the Road with the Trouble Man

By M. S. Howard

It is surprising how an ice plant can keep on going while in bad shape. In fact, one is quite safe in saying that a large number, especially the older ones, are not run efficiently.

Last summer our office got a hurry-up call from an ice plant in Louisiana. The manager explained over the telephone that the capacity of the plant had been going down and while they had been getting 100 tons of ice per day in May, only 60 tons could be produced in August. I caught a mixed freight and arrived early the next morning.

After getting breakfast at the railroad eating house, I walked up the track toward three smokestacks that were belching out dense clouds of smoke. On entering the boiler room, I found two negro firemen using No. 2 scoops to shovel slack coal into the boiler furnaces. I could see through the open firedoor that the fires were from one to two feet thick and the firemen were ready to put on a few more shovelfuls.

Upon my asking why the excitement, the negro foreman informed me that "the engine was a sure steam eater. Couldn't keep the pressure up no ways." I was quite willing to concede that there seemed plenty of evidence to help him back up his statement and so drifted into the engine room.

The ice machine was a horizontal double-acting compressor, direct connected to a Corliss engine. That the machine was heavily loaded was shown by the long cutoff carried by the engine; the valve latches were not unhooked by the knockoff cams until almost half-stroke and occasionally failed to unhook, causing the cylinder to take steam full stroke, whereupon the engine would lung and speed up. Here I found the engineer busily nursing a hot crankpin on the compressor. As soon as I made myself known, the way his face cleared up was surprising. He seemed to think that he could now sit down and turn the plant over to me.

I spent the morning going over the layout, making notes of the things that I could see were out of order. The condenser pressure was around 200 lb. although the cooling water was 68 deg., which should have given a condenser pressure of 140 lb., allowing a temperature drop of 12 deg. between the water and the ammonia.

After a while the manager showed up. My appearance on the scene apparently gave him a lot of pleasure, although he said he doubted if I could fix up things. The overloading of the boilers was, of course, of importance, for the coal bill was high enough for a plant of twice the tonnage. The overworked engine didn't please him, for there was always the worry that something would break. But the vital thing was the drop in ice manufactured; the hot season was on when even the negroes bought a nickel's or a dime's worth of ice each day. The town needed ice and intended to get it.

To make matters worse the plant, which, although steam-driven, had a raw-water ice system, was losing at least 10 per cent of the cakes by cracking. This was marketable, but the purchaser always demanded a 20 to 50 per cent discount.

Evidently, my job was cut out for me. Some might have started the trouble correcting at the boiler room or at the ice dump, but I felt that the real difficulty was in the compressor and condenser, so started at the former. This was a double-acting machine with the usual equipment of valves and pipe connections. The stuffing box was suspected as being the cause of the high condensing pressure, the latter being, I was sure, due to air getting into the system. The lantern of the stuffing box had been equipped with a liquid line to keep the rod cool. Some engineer had evidently thought this connection unnecessary and the pipe line had been removed. The end of the nipple entering the lantern had been closed by a check valve opening inward so that no gas could blow out the pipe. The result was that, although as long as the machine was running no air could enter, whenever the machine was shut down and a vacuum pumped, air leaked in and filled the cylinder. During the winter and spring the machine was stopped every night, so the air entering the system amounted to a great deal. The engineers attempted to eliminate it by purging, but by reason of the condenser connections little air but a lot of ammonia was blown out of the coils.

The first steps were to fix the compressor lantern and to clean the system of air. The condenser was in four stands, so we cut out one set of stands and not only ran cooling water over the idle coil for a long time, but went so far as to connect up a hose line to the forecooler and so finished up with water at 40 deg. This brought the coil pressure down to 95 lb., or 110 lb. absolute. Of this pressure the ammonia at 40 deg. made up 73 lb., while the remainder of 37 lb. was due to air. The coil was then purged until the pressure dropped to 80 lb. also. The weight of ammonia vapor per cubic foot at 40 deg. F. and 80 lb. pressure is 0.2526 lb.; air at this temperature and at a pressure of 37 lb. weighs 0.2 lb. per cu.ft. Where purging reduced the pressure of 80 lb. the ammonia at 40 deg. still exerted 73 lb. pressure, the vapor lost by purging being replaced by some of the liquid evaporating. Air at 7 lb. (80-73) pressure and 40 deg. F. weighs 0.04 lb. per cu.ft. Purging has then removed 0.16 lb. of air per cubic foot of condenser volume. The ammonia lost will be approximately 0.2 lb. per cu.ft. of condenser space. Consider that the volume be 10 cu.ft.; there was 2.526 lb. of ammonia and 2 lb. of air before purging. After purging, the 10 cu.ft. contained 0.4 lb. air, or 1.6 lb. was lost, which is equivalent to 8 cu.ft. Then the 8 cu.ft. also contained $8 \times 0.2526 = 2.02$ lb. of ammonia gas which was lost by purging. It is evident that purging is expensive although necessary under the circumstances. The ratio of air to ammonia after purging was 0.04 to 0.2526, or almost 16 per cent by weight. This same method was carried out on all the stands, not once but four times, so that the operating condenser pressure fell to 150 pounds.

The load on the engine dropped, as was indicated by the position of the governor weights; before purging, the governor was down on the collar and the engine operating with the largest possible cutoff. The bearings began to cool off and the pounding stopped. The engineer's face began to clear for he thought we would finally make the grade.

I next went into the ice tank and coils. One thing that struck me was the few expansion cocks, considering the tank capacity. Upon asking the manager, I found that the coils were 1,800 ft. long. This meant a lot of resistance to the flow of ammonia liquid and the ammonia gas. In consequence their pressure in the coils at the cocks was five pounds higher than at the suction elbow of the compressor. This meant that the compressor suction pressure was five pounds lower than need be, and to pull out a given weight of ammonia gas the compressor had to run faster than required with the higher suction pressure. Alteration in the coils could not be made as long as the plant was in operation. However, we made plans to change to coils when cold weather came on; each coil was to be cut into three 500-ft. sections, and an accumulator was to be installed to permit working on the flooded system.

Cracking of Ice Eliminated

One thing was found that could be changed. The cracking of the ice cakes was due to the cold brine temperature. The ice was frozen and then lowered in temperature to something like 20 deg. since the brine was carried at 9 deg. When the can was pulled, the negro puller moved it to the dump and ran over enough water to thaw the outside so the cake would slip out of the can. The cake was at 20 deg. F. and as the outside warmed up it began to shrink, for ice shrinks at a rise in temperature. The inside, of course, could not give and as a result the cake cracked. It was our opinion that if the time of melting was shortened only the skin of the cake would warm up. Then, by immediately shoving the cake into storage, the heat would not go deeper and cracking would be avoided. It was difficult to get the ice pullers to do this, but by showing them that about 30 cakes a day cracked and offering a bonus of 10 cents a cake for any decrease in the number cracked each day, the loss dropped to two or three.

The reduction in condenser pressure enabled us to speed the machine up a little so that we could let the brine temperature go up to 12 degrees.

I felt that but little more could be done to the ice, and so attention was given to the boiler room. It has been mentioned that the plant operated non-condensing, so the first thing I suggested was the putting in a condenser. This of course would take time and could not be done during the season. The only hope of bettering the boiler room was to increase the evaporation per pound of coal. The boilers, although the water was very hard, had not been cleaned since spring. One boiler was pulled off the line and the plant load dropped so the others could handle it. Upon opening the idle boiler, about half the space between the tubes was found to be choked with scale. A man was put in with a scaling iron and a day's work resulted in four wheelbarrow loads of scale. While this was going on another man was put to cleaning the inside of the tubes.

For some reason the brick walls were in good shape, as were the grates. After putting this boiler back on the line, a second was cooled off and cleaned. I never saw so much scale in my life. After all was fixed up, we found that two boilers handled the load without effort. The firemen were able to load half the time and the coal wheeler was discharged and the firemen wheeled in the coal.

Smaller Furnaces for Pulverized Coal?

WHEN inspecting old catalogs, textbooks and other engineering literature of, say, 25 years ago, the engineer of today is rather humorously impressed by his predecessors' attempts to get the boiler down "where the fire is hottest." About the only limitation, apparently, was the necessity of leaving a few inches of space for coal between the tubes (or shell) and the grate.

Then the discovery was made that heat will "keep," that it need not be absorbed the moment it is produced. So boilers were gradually moved up from the grates to prevent chilling the gases before combustion was complete.

Thus there came about a great increase in furnace volume per unit of boiler-heating surface. Only a few years ago it was an exceptionally large furnace that had one-tenth cubic foot of combustion volume per square foot of heating surface. In most of the large plants erected during the past few years the furnace volume lies between three-tenths and eight-tenths cubic foot per square foot of boiler-heating surface, averaging about four-tenths for the underfeed-stoker-fired stations and seven-tenths for pulverized-coal installations; some run considerably higher.

This ratio has the advantage of being definite. It is, however, a less rational basis of comparison than the combustion rate expressed as B.t.u. developed by the fuel per cubic foot of furnace volume per hour. Obviously, if one boiler is to be operated at a higher percentage of rating than another, it will require correspondingly more furnace volume, other things being equal.

Thus it would obviously be unfair to assume that a boiler erected in 1910 with a ratio of one-tenth had only one-quarter the volume needed to burn its fuel properly, merely because many modern designers use four-tenths. Consideration must be given to the higher ratings now used and the correspondingly increased coal consumptions per square foot of heating surface.

Thus one of the old boilers with a one-tenth ratio of combustion volume to heating surface would, when operating at rating, consume about fifty thousand B.t.u. per cubic foot per hour. A modern stoker-fired installation, with a ratio of four-tenths and operating at three hundred and fifty per cent of rating would consume about forty thousand B.t.u., while a pulverized-coal installation, with a factor of seven-tenths, would handle only about twenty-two thousand B.t.u. per cubic foot.

Thus it is seen that it is the custom to allow considerably more volume for the combustion of pulverized coal at a given rate. The necessity of this might be questioned. Could not the extra cost of the larger setting be avoided in some way? It must be admitted that with stokers much of the combustion takes place in the fuel bed, the unburned remainder being supplied to the combustion space in gaseous form. On the other hand, oil fuel has been burned with mechanical atomization at rates as high as one hundred and seventy-six thousand B.t.u. per cubic foot per hour.

In this connection particular interest attaches to the statement made the other day by E. H. Couch, of the Narragansett Electric Lighting Co., that combustion rates as high as thirty-nine thousand had been obtained in his plant by sticking horizontal coal burners into an old low-set furnace previously fired with oil. In spite of the fact that practically nothing was done to the furnace beyond attaching the burners, an efficiency of eighty per cent was obtained, equaling the specially designed pulverized-coal furnaces operating at combustion rates ranging from twelve to twenty thousand B.t.u. per cubic foot per hour in the same plant. Refractory troubles brought the experiment to a temporary halt, but it looks like a promising field for further investigation. It would seem that the brickwork could be protected by air or water cooling. Ability to get the maximum capacity from small volumes should be particularly advantageous when changing old boilers over to powdered coal.

Where Engineers and Accountants Co-operate

SIGNS of a new day in the relations of engineers and accountants appeared at the recent convention of the N.E.L.A. in Atlantic City, when H. P. Liversidge, of the Technical Section, addressed the Accounting Section on "Accounting from the Engineer's Viewpoint" and cited cases where co-operative effort on the part of operating men and accountants is saving many thousands of dollars yearly in plant maintenance. In the past too many operating engineers have looked upon accounting as a pestiferous device calculated to "gum up the works" and to distract attention from the problem of producing power at the lowest fuel consumption per unit of output.

On the other hand, the accountant, as a rule, has had little understanding of the engineer's language and equipment.

In these days of construction and operating budgets it would be superfluous to undertake to demonstrate to engineering intelligence the value of cost analyses in the power plant. Every engineer worth hiring knows that regular comparisons of operating results are essential to check waste. Mr. Liversidge reviewed the old non-understandings between engineers and accountants in a manner that aroused no little interest at the convention; but the most significant part of his paper dealt with the relation of the accountant to maintenance.

In one plant where the accountants and the engineers

put their heads together, excessive repairs to ash hoppers were a handicap. These were redesigned after the accountants' analyses showed the chief outlays in subdivided costs of maintenance, renewable metal surfaces being provided along with better-shaped hoppers that in toto cut down the cost of operation about seventy-five thousand dollars a year. In another plant co-operative cost analysis followed by a new design of wheels for coal-handling cars saved two thousand dollars a year, and in a third station nine thousand dollars a year was saved in repairs by changing over the stoker drives from group to individual motors.

It was apparent from this address that the future is going to witness a much better co-operation between these two important groups of workers. The engineer must realize that the accountant is no longer a high-grade bookkeeper only, and the man of figures must get acquainted with the fellow behind the turbine and boiler house walls and learn to understand his language.

Increasing the Working Temperature of Steam

THERE appears to be no particular rush to increase steam temperatures. Although oil-refining processes are at present in operation at eight hundred to nine hundred degrees F., steam engineers look upon reliability as such an important matter that increasing the present working temperature will probably be slow and subject to lengthy practical demonstration. There are, nevertheless, definite incentives to increase temperatures and, as a means of improving economy, this will probably receive more attention than in the past.

Fundamentally, steam temperature defines the efficiency of the Carnot energy cycle to which engineers may work as a limit. As yet the most advanced practice has not achieved more than one-half the efficiency made possible by seven hundred and fifty degrees F. steam. Therefore increasing the temperature provides an alternative measure for obtaining better economy to the more elaborate regenerative and reheating arrangements.

In the past it has been more convenient to elevate pressures, relatively speaking, than temperatures. The latter involves decreasing the strength and elasticity of material, together with the requirement of greater elasticity due to increased expansion. As a matter of fact, however, greater thermal advantage may be gained by the increase of temperature than that of pressure, relatively speaking. Thus, if we consider steam at two hundred or four hundred pounds pressure, at seven hundred degrees F. total temperature, either one of these pressures may be doubled with a certain definite gain in Rankine-cycle efficiency. On the other hand, if the temperature be increased from the initial condition to eleven hundred, an equal gain will result, although this represents only about thirty-five per cent increase of absolute temperature against doubling the absolute pressures. If practicable, it would be much more desirable thermally to double absolute temperatures than pressures.

Increasing the steam pressure is limited by the critical pressure of steam as well as by the fact that above one thousand to twelve hundred pounds there is little gained at present steam temperatures. Raising pressures has been looked upon with favor on account of providing a method of increasing capacity as compared to space and material.

With regard to the utilization of higher temperatures, it must be remembered that if conditions warrant the use of temperatures comparable to those of a Diesel engine, an amount of work may be done in expanding to the present steam temperatures and pressures equal to that in expanding from such points to a vacuum. As in other forms of prime movers at temperature extremes it is not improbable that cooling elements must be employed in addition to providing only a short time interval of exposure to hot gases, followed by a cooling period.

Coal Land Valuation

AFTER a good deal of a struggle the Lehigh Valley Coal Co., the Hudson Coal Co. and the Girard Estate, the largest holders of coal lands in Schuylkill County, have "agreed" with the County Commissioners on an increase averaging more than 150 per cent in their taxable value. The anthracite lands of Schuylkill County were assessed in 1919 at $53,000,000. On the basis of the "settlement" the owners stand to pay taxes on a valuation of approximately $132,000,000.

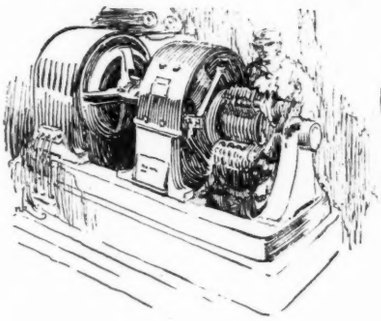
In 1922 the Board of County Commissioners, assisted by engineers, fixed the value for tax purposes at $422,000,000, or 60 per cent of the estimated real value.

What value is used upon which to compute interest and depreciation in making up the "cost at the mine"?

"The ten ways to evil in the time of Moses have increased to ten thousand now," said Secretary Hoover in his address to the United States Chamber of Commerce in Cleveland recently. A great many of these "ways to evil," have to do with the industry, finance and trade of the world. These evils have brought a deluge of laws. That deluge will continue, says the Secretary of Commerce, unless business is willing to help clean its own house, stop its own wastes and end its own abuses. His speech was a warning to business as well as a preachment of old-fashioned honesty. There are twenty-five thousand business associations in this country, and Secretary Hoover calls upon them to "devise out of the conscience and organization of business itself," the needed restraints and curbs and to assume this task and carry it through so far that legal regulations will not be necessary.

The Senate Printing Committee reported on May 26 to the Senate, without amendment, a concurrent resolution, introduced on Dec. 16 by Senator Oddie, providing for the printing of the "United States Coal Commission Report," made in 1923. One wonders as to the use of printing a report, which cost so much in effort and money, and which revealed so much that was vital to every person in the country, when nothing has yet been done by Congress with regard to carrying out the recommendations of the Commission. It would seem that, after having spent many thousands on collecting and preparing the report and another $22,000 on printing it, Congress might presently awaken to the fact that what the nation would like is some real action on the report itself.

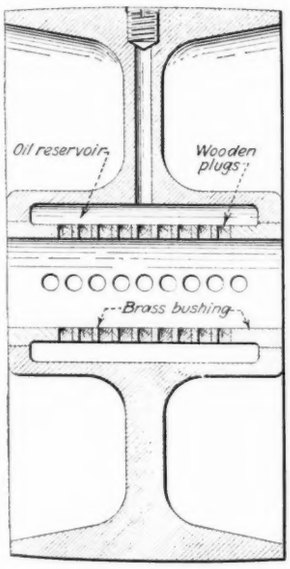
It is unfortunate that Senator Norris has sought to substitute conjectures for matters of record in his report on Muscle Shoals. Reaction to his insinuations regarding both the President and Mr. Ford in the replacement of the Gorgas plant are likely to discredit points of merit in the report.



Practical Ideas *from* Practical Men

Loose Pulley Troubles

To many engineers the loose pulley is a never-ending source of annoyance. Numerous articles have been written that offer a variety of solutions for overcoming this trouble. One of these, by Mr. Wakeman, in the March 4 issue, offers some good advice, but in my opinion he misses the best cure of all. Nearly thirty years ago I had charge of a large amount of machinery having loose pulleys, and one of these owing to its high speed, gave considerable trouble. After numerous attempts to effect a cure without success, I found in the *American Machinist* the idea shown in the illustration, which I have since applied to hundreds of loose pulleys.



Hardwood plugs are inserted in the brass bushing

The illustration requires little explanation. A brass bush perforated with a series of holes in which hardwood plugs are fitted, is inserted in the hub of the pulley and is chamfered to form an oil reservoir. With the bush properly fitted, a pulley that runs very smoothly is obtained, no oil is wasted, and no attention is necessary for periods up to six months according to the capacity of the oil chamber.

This method is highly successful for pulleys in out of the way places, such as on crane jibs, hoists, etc. Considering the success of this idea, I have often wondered why our machinery makers do not apply it in a general way to all loose pulleys and thus save a great deal of annoyance and reduce the waste of oil.

Belfast, Ireland. F. P. TERRY.

Why Not More Vertical Turbines?

The question that follows has more than likely been on the minds of a good many operating engineers throughout the country, and I am sure that a great many are interested in the answer.

Why is it that the old vertical turbines have not been redesigned and brought up to the present standard of efficiency as in the case of the horizontal machine?

I do not think that I am alone in stating that there are several important features of operating in which the vertical type far surpasses any horizontal turbine built, especially in the larger sizes. I refer only to units over, say, five thousand kilowatts.

One feature is their ability to stand a quick start-up from a standstill. Another is that no disastrous results mature from having a leaking throttle, and if for any reason the vacuum is lost, there is little danger of a fatality.

The first item makes them valuable machines for stand-by purposes and in places where thunder showers and the like make quick-rising peak loads. I have worked in a plant where a unit was put on the line from a dead standstill in from three to four minutes. Such abuse to even small horizontal turbines would end in trouble.

There is of course one disadvantage in the step bearing, although I see no reason why any trouble should be incurred on that score if strict rules regarding that part are adhered to.

There are several other advantages, too lengthy to enumerate here, which make them a better machine to operate. However, I should like to know what is the fundamental reason for their apparent discard.

El Paso, Tex. JOHN H. MORRIS.

Removing Cylinder Head and Piston from Unaflow Engine

Some time ago the management decided to shut down the factory for a week to make some alterations. Having charge of the power plant, I decided to take advantage of the shutdown to look into the cylinder of our 1,000-hp. unaflow engine, which had been in constant service a few years.

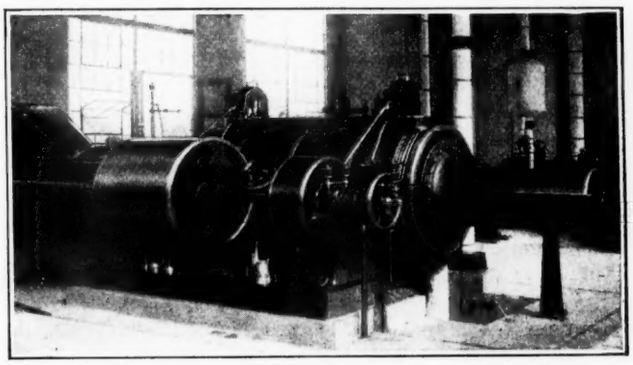


Fig. 1—General view of 1,000-hp. unaflow engine

The steel framework constituting the roof support was not strong enough to support the heavy parts to be raised, so about two weeks before the shutdown we decided to construct a timber framework from which

the heavy engine parts could be suspended. Six posts 8x8 in., 11 ft. long were erected ahead of the engine, three on each side, and braced temporarily. One post was cut shorter and set upon the sub-base of the governor and eccentric housing.

On the top of these posts two 4x8-in. timbers 18 ft. long were placed, then three 6x8-in. cross-ties 8 ft. long were laid across, one on each end and one in the center. A hole 1x2 in. as at *A* was made in each post about six inches from the end before they were erected. After the cross-ties were in place, a 1-in. hole was bored down through the cross-tie into the post to a depth of about 8 in. Pieces of $\frac{5}{8}$x2-in. flat iron, 8 in. long with a hole drilled in the center and threaded was placed in the hole at *A* and a long bolt put in from the top and screwed down tight. On the corner posts two flat iron braces were fastened and on center posts three braces each. The braces were made from $\frac{5}{8}$x2-in. flat iron, 3 ft. long with two $\frac{5}{8}$-in. lag screws in each end. When the framework was completed, a 10x4½-in. I-beam was drawn up and bolted to the cross-ties. Three trolleys were taken off a traveling crane in the factory and placed on the beam.

The piston of the engine is 24 in. in diameter and 32 in. long with three rings on each end. The piston rod is 6½ in. in diameter and 16 ft. long. The end of the rod has a taper fit in the crosshead and is drawn tight by a wedge 1¼ in. thick and 5 in. wide. The rod was driven loose from the cross-head with the wedge as shown in cross-section at *C*, Fig. 2. In removing the rod, the wedge was first driven out, then fillers, made as shown in detail, at *D*, *E* and *F*, were inserted for the key to work against in forcing out the rod. The fillers *D* and *E* were made by chucking a piece of 1¾-in. shafting in the lathe off center and cutting one side with a boring bar to fit the edge of the wedge, the sides being planed off where necessary.

In making the filler *F*, a hole was drilled through a piece of shafting and one side sawed out. Of course the wedge did not enter as far as formerly, but entered enough to take good hold, and then with three men on a piece of 3$\frac{15}{16}$-in. shaft 6 ft. long, the wedge was driven in and the rod drawn loose.

A chain sling was then placed around the tail-rod housing, and a strain taken on the chain falls and the rod removed. Two eyebolts were screwed in the head of the steam-valve bonnet and two chain falls applied as shown in the illustration. A slight strain was taken on them and all nuts removed from the cylinder, steam and exhaust flanges. By attaching a rope block and tackle to the wall of the engine room and the other end to a rope sling around the tail-rod guide, the entire mechanism was drawn forward.

When an examination was made, we found that new piston rings were needed and they were wired for immediately. It required a little over half a day to have the piston out in the clear, the preparations being made while the plant was running, to expedite the work when the plant was shut down.

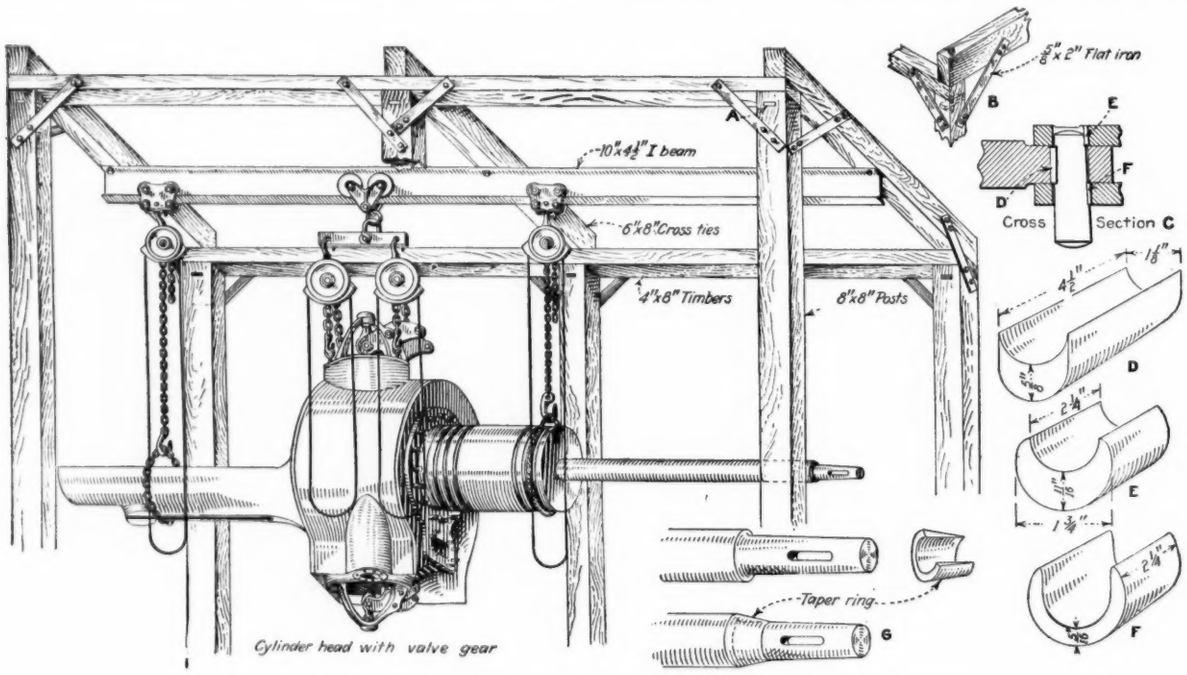


Fig. 2—Framework and tackle employed in removing the piston

We used metallic packing on both ends of the piston rod, and when the rod was withdrawn, this packing contracted. We realized that the short offset on the rod would not enter the packing again, and as we did not wish to disturb the packing, a taper ring was turned up on the lathe and slipped over the rod as shown at *G*.

When the new rings were in place, the entire rig was transported back toward the cylinder of the engine, and when at the proper location the head was lowered and the piston rod started through the back head. The taper ring was oiled as well as the walls of the cylinder, and when the end of the rod was through the head, the taper ring was removed. When everything was again assembled, a trial run was made and the engine was ready for service.

After the plant was again in regular operation, all parts of the frame were marked, then taken down and laid away for future use.

ANTONY A. FETTE.
New Iberia, La.

Comments from Readers

Feed Pump Steambound With Highest Feed-Water Temperature

Referring to the inquiry of M. W. in the April 29 issue, I would suggest that, if the heater from which the pump receives its supply of water is equipped with a hood over the end of the suction pipe, he examine the vent pipe and see that it is clear. Also, if there is not much head on the suction line or the pump is a considerable distance from the heater, a standpipe on the suction line close to the pump might substantially improve its operation. A. W. McNETT.

Cortland, N. Y.

Utilizing Boiler Blow-Down

The editorial in the April 1 issue on "Utilizing Boiler Blow-Down" brings to mind an installation in an isolated lighting and heating plant where the boiler blow-down was utilized to heat the service water. The plant, in addition to the lighting service, furnished a considerable quantity of hot water to several adjoining buildings at a temperature above 130 deg. The plant was located in a new building, and other adjacent buildings had been remodeled to suit new tenants. When all were completed, it was found that the exhaust steam, after passing through the open feed-water heater, was not sufficient to heat the required amount of water, so live steam was used. The demand finally became so heavy that the water could not be heated fast enough in the one heater and it was thought another heater would have to be installed. Though ample space has been made for extra engines and boilers, space for this piece of equipment was at a premium.

The boilers were arranged to blow down through a blowoff tank to a sump well in the engine-room floor close to the hot-water heater. All the drips from the steam traps, cylinder drain traps and drains from the steam mains discharged into this sump, and a large amount of heat was lost as steam was constantly escaping. The engineer suggested to the owner, who had previously been an engineer, that by placing a coil of 2-in. pipe in the well the temperature of the water could be raised considerably before it was pumped through the closed heater, and in this way the present heater capacity would prove sufficient. The owner readily consented, and the coil of pipe was put in with a few turns of the coil above the average level of the water. The results were much better than was expected, the water being pumped through the coil in the sump well, then through the house hot-water heater to the customers and the offices of the main building.

Similar arrangements could undoubtedly be used in many isolated plants where a large amount of hot water is required and where the blowing down is done at frequent intervals, or where a number of drains are led to the blowoff tank.

In some cases it may be practical to pass the feed water through the coil installed in a blowoff tank and thereby reclaim considerable heat that would otherwise be wasted. This of course would call for more steam to operate the pump, so each case would have to be considered on its own merits. In the case just mentioned, the installation of the coil in the blow-down tank gave the necessary heating capacity and obviated the installation of an additional heater. R. A. CULTRA.

Cambridge, Mass.

American and European Hydraulic-Turbine Practice

In *Power* of May 6, under "Comments from Readers," appeared a letter from the chief engineer of Escher Wyss & Co. of Zurich, which referred to my letter in the Feb. 19 issue on the subject of "American and European Hydraulic-Turbine Practice." While not wishing to burden your columns with an unduly protracted discussion of this subject, which seems to have assumed a highly controversial aspect, I feel that I should not ignore Mr. Seidl's comments.

In characterizing the state of the art in Europe as being "backward," I was using this term merely in a relative sense in comparison with present American practice. I fully appreciate the severe economic handicaps which the European engineers have had to contend with, including the effects of the war and the limited water-power resources of Europe mentioned by Mr. Seidl; and I did not wish to reflect on the work of the European engineers, but merely to call for a better recognition of the actual conditions existing without going into the reasons for their existence.

The slow progress made in Europe in adopting a number of important features of American practice which have been thoroughly demonstrated in America, including the modern American type of high-speed, single-runner, vertical-shaft turbine, is evident to anyone familiar with the European practice of the last ten years. Even the propeller type of turbine, while treated by certain European engineers as if it were entirely of European origin, was widely and successfully applied in American practice when it was still in the theoretical and experimental stage in Europe.

The thought that has prompted me to bring out the points I have raised is the general attitude of superiority still displayed by many European writers (I am not referring to Mr. Seidl) and the effects of European propaganda as evidenced by the impression still sometimes found even in America—that American engineering is necessarily inferior and unscientific. For example, it has been contended for many years by certain European writers that American turbine tests are unreliable and that all American efficiencies must be discounted. It is only in recent years, since the results that we have been securing have been more closely approached in Europe, that European engineers have been found willing to admit the credibility of American test reports. A trace of the idea common in Europe is shown in Mr. Seidl's letter when he asserts that "the

whole of the modern American turbine design is built up on scientific work of European hydraulic engineers such as Pfarr, Camerer, Prasil, Allievi, Dubs and various others." It seems to me highly absurd for anyone to think that we design turbines from textbooks. As a matter of fact, the development of the American hydraulic art in the last twenty years has been entirely independent and has involved the creation of new theoretical and experimental developments to meet new problems, and has resulted in carrying the American turbine into new fields of capacity, head, speed and efficiency which have not even yet been reached in European practice. American practice has not followed any textbooks or other publications, but has at all stages been far in advance of anything to be found in books either American or foreign. Books almost invariably follow at least five years behind the actual development of the art, and this is particularly true in hydraulic-turbine practice.

Referring to Mr. Seidl's remark as to the employment of Swiss engineers by American firms, I might state that the work of our own company has been carried out by American engineers and that we have not been dependent upon any European engineers, although we have in the past helped to train a number of them in this field of engineering.

In the paper presented by me at the meeting of the National Electric Light Association a year ago, which I believe was responsible for the discussion that has followed in the pages of *Power*, it was my endeavor to give full credit to the accomplishments of the European engineers in this field, and I particularly mentioned the contributions of European engineers to the theoretical knowledge of turbine design and the value of these contributions in American practice of twenty or twenty-five years ago, and I mentioned the building of one of the early Niagara turbine installations from the designs supplied by Escher Wyss & Co.

H. BIRCHARD TAYLOR, Vice-Pres.,
Wm. Cramp & Sons Ship & Eng. Bldg. Co.
Philadelphia, Pa.

Heat-Work Conversion Law

In the March 25 issue W. R. Williams questioned some of the present concepts concerning the laws of heat-work conversion, and in presenting his argument he makes a number of totally unjustifiable thermodynamic assumptions. All his conclusions are drawn from a *heat* analysis using the pressure-volume (or work) diagram as a basis. Such a use of this diagram is absolutely wrong, as is well shown by the absurdity of his deductions.

In the first place I think he misunderstands the very meaning of the word "conversion," as in the last part of the third paragraph he refers to "the work done by the converted heat" and "that done by the non-converted." The word "conversion" is used in thermodynamics to indicate the portion of heat added in any cycle that *is converted* into work. How, then, can work be done by the non-converted heat, as Mr. Williams assumes? Referring to Fig. 2, simply because the heat rejected along the line *CL* is 50 B.t.u., there is no justification for assuming that a corresponding part of the *work done* is not a conversion of the heat in the fluid. The fact that only so much heat is rejected is a good indication that the rest is converted to work. It seems to me that Mr. Williams wants to throw away some extra heat during the expansion and then wonder where all the work comes from when the cycle is complete.

When the expansion from *H* to *C* occurs, the fluid has no knowledge that its condition is later to be guided along *CL* and *LJ*; it does not, while expanding, "save" 50 B.t.u. to reject later, but merely does work as represented by the area *EHCF*. The rejected heat is then dependent only on the pressure difference between con-

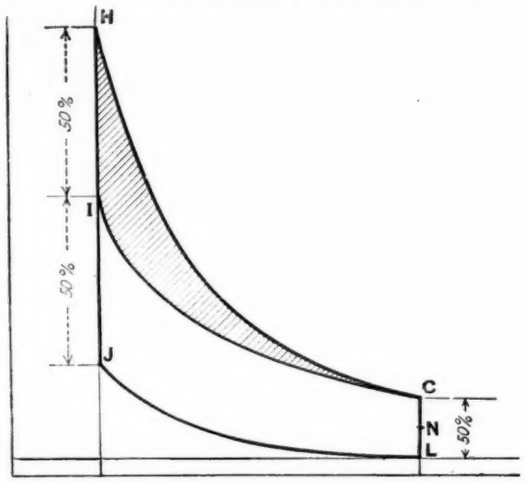


Fig. 1—Diagram shown by Mr. Williams

dition *C* in the cylinder and condition *L* outside at the time of opening of the exhaust valve. Now, following Mr. Williams' theory, suppose the stroke is shortened to *C'* instead of *C*, the rejection is greater and the efficiency less than before, but the fluid, not being forewarned of the shortening of the stroke, still converts heat as represented by the area between *HC* and *IC*, though stopping at the Line *C'M*, of course. However, by the previous assumption, the conversion in the new cycle *L'JHC'* should be indicated by the area *I'HC'*, which is quite different from *IHC'M*. Thus the theory leads to an absurdity and so must be false.

In order to study the cycle in its true light, let us transfer it to the temperature-entropy diagram (Fig. 3), where areas represent heat quantities instead of work quantities. The symbols used are the same for the same points as in Fig. 2, so that corresponding paths may be readily seen in both figures.

The area *AJHB* represents the input and *ALCB* the rejection, leaving *LJHC* as the heat converted to work. It is obvious from this diagram that the line *IC*, which is "50 B.t.u. above *JL*" (along a constant volume path), has no meaning whatever, and that Mr. Williams is not justified in assuming that only the area *IHC* is converted. The area *LJIC* plus area *IHC* together indicate the *converted* heat and are equivalent to the work done as represented by the area *LJHC* in Fig. 2. As already suggested, the point is that the pressure-volume diagram does not show the whole story and that the heat flow is not proportional to any length or area on that chart.

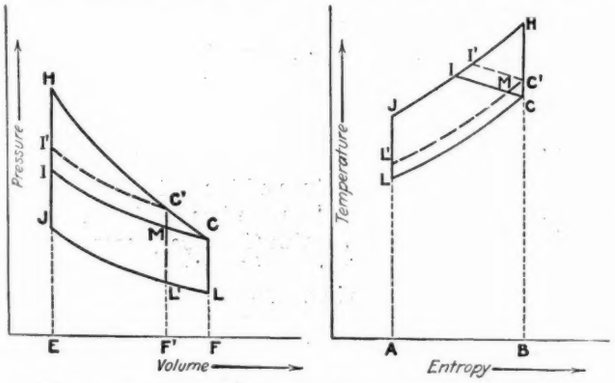
In the fourth paragraph of his letter Mr. Williams attempts to prove his unconverted heat assumption, and in so doing he speaks of the existence of heat as such acting to maintain pressure. This is undoubtedly true, but he entirely overlooks the fact that "total heat" in an absolute sense is something of which we know little, and that the heat quantities used in connection with

working fluids are those added or taken away along certain specified paths. Thus two separate portions of the same fluid may be carried along different paths to the same final pressure (but different temperatures) and be widely different in respect to heat added and work done.

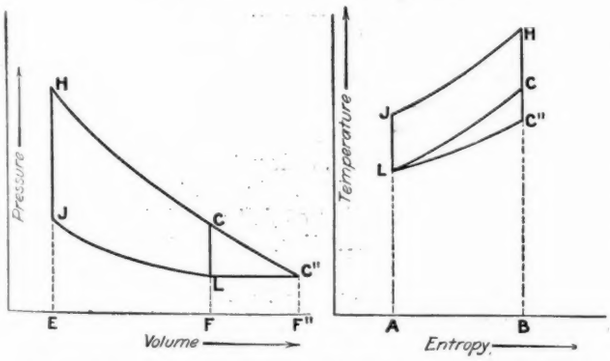
If Mr. Williams' theory is correct, it should be applicable to all cycles. Let us therefore attempt to apply it to the Humphrey Cycle (Figs. 4 and 5), which is used in certain internal-combustion water pumps in England. In this engine the gas pressure acts directly on the surface of the water pumped and the stroke is not fixed. Thus the expansion extends to the back pressure and the cycle differs from the Otto cycle only by the addition of the "toe" (area *CC"L*) of the indicator diagram. How should the conversion line be drawn now? Since the line *CL* (Fig. 4) has shrunk to zero, do we infer that there is no heat rejected in the exhaust? On the contrary, Fig. 5 shows very clearly that the rejection is the area *ALC"B* and the heat converted is *LJHC"*.

In conclusion, I wish to stress the importance of a clear knowledge of the limitations of both the pressure-volume and the temperature-entropy diagrams in thermal analyses. In general the wrong use of one will be readily apparent when compared with the other, and I cannot urge too strongly that full use be made of this check comparison when unusual questions arise.

New York City. ROBERT B. DONWORTH.



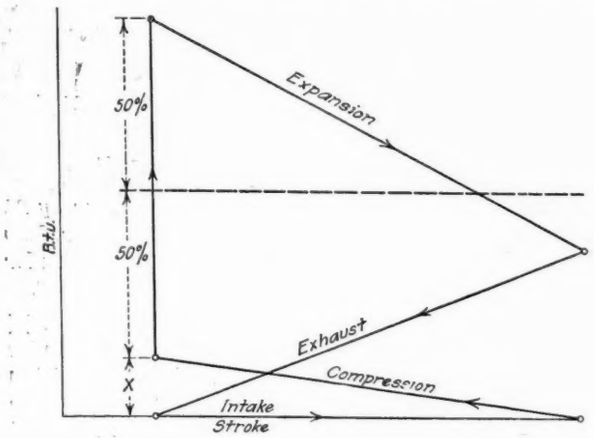
Figs. 2 and 3—Otto cycle in pressure-volume and temperature-entropy diagrams



Figs. 4 and 5—Humphrey cycle in pressure-volume and temperature-entropy diagrams

Mr. Williams' apparent fallacy in the law of heat conversion is based on his mistaken idea that, in the pressure-volume diagram that he uses, the pressure scale can be replaced by an equivalent B.t.u. scale. This is not the case, since the B.t.u. is a unit of work or energy and pressure merely one of force, which must act through a distance to produce work.

Even if it be assumed that the 50 B.t.u. addition goes to increase the temperature and pressure of the contents of the cylinder, the catch is in "question 2" and the "identical" half-portion. The two halves are identical along the line *JH*, but from there on the heat can be



Cycle plotted with B.t.u. as ordinates

transformed into work only by the falling of the whole amount in temperature, and the heat units at a lower temperature cannot be directly compared with those at a higher temperature since they have not the same capacity for transformation into work or for transfer from one body to another.

Scientifically, this is called entropy, but it is merely the expression of the every-day experience that while steam at atmospheric pressure has 95 per cent of the heat units of steam at 150 lb., and even at 28-in. vacuum has 90 per cent, yet it is not valuable for the production of power in anything like this proportion.

What Mr. Williams apparently intended to draw is a B.t.u.-stroke diagram, but this is an altogether different figure, roughly shown in the sketch. The B.t.u. ordinates represent only sensible heat of the charge at different points of the stroke. In this diagram, unlike the pressure-volume diagram, areas have no physical meaning. The reference point of the B.t.u. scale is taken at intake temperature so that on the basis that any real quantity times zero is zero, the variation in quantity of charge in the cylinder does not affect the B.t.u. content. The quantity *X* represents energy stored in the flywheel during expansion and returned during compression. This discussion of course assumes a theoretical engine with adiabatic expansion and compression and none of the actual losses in the usual four-cycle engine. H. D. FISHER.

New Haven, Conn.

Method of Socketing Cables

Referring to the inquiry of J. M. Naylor in the April 22 issue as to a method of socketing cables where a blow torch cannot be used, I would suggest that if he has electric current in the mine, he use a 1,000-watt electric heater and melt lead at 600 deg. F. (assuming that mine gas will not ignite at that temperature) and use it in the rope socket. E. W. NAYLOR.

Chicago, Ill.

QUESTIONS AND ANSWERS

Conducted by Franklin VanWinkle

Volume of Steam Present at Cutoff

If the cylinder of an engine is 16 in. diameter by 24 in. stroke, and there is 5 per cent cylinder clearance, how many cubic inches of steam are present in the cylinder when cutoff occurs at ¾ stroke? *S. P.*

The piston displacement per stroke would be (16 × 16 × 0.7854) × 24 = 4,838.4 cu.in., and if the cylinder clearance spaces amount to 5 per cent of the piston displacement, the total volume of steam present when cutoff occurs at ¾ of the stroke would be ¾ of 4,838.4 plus 5 per cent of 4,838.4 = 3,870.7 cu.in.

Setting Slipped Eccentric of Link Motion

In case of slippage of one of the eccentrics of a link valve motion, how can the proper position for resetting be found? *B. N.*

Place the engine on a center. If the forward-motion eccentric has slipped, place the reverse lever in the extreme back notch, then mark the valve stem close to the gland and place the reverse lever in the extreme forward-motion notch. Then, remembering that the eccentricity or full part of the eccentric must be on the opposite side of the crank, turn the loose eccentric around on the shaft until the mark on the valve stem comes to the place where it was made, and secure this eccentric to the shaft.

Groaning of Pump

We have a small single-tank pump that is used mostly during the night and has become a nuisance from making a groaning noise. What is the cause and how can the trouble be prevented? *W. F. S.*

The noise probably arises in the water end of the pump from eccentricity of the water piston packing, causing the piston rod to be held to one side of the rod packing. Remove the rod packings and observe whether either or both water and steam end rod packing are worn most on one side. This also would occur from unequal pinching by the packing from improper size of packing, eccentricity of the stuffing box, careless placing of the packing, setting the gland nuts unequally, or to having beveled ends in the stuffing box or gland.

To determine whether the piston travels in proper alignment, remove the rod packing from the stuffing box of the water end and observe whether the rod moves up and down or sideways in the stuffing box when the pistons are moved the full length of a stroke. If so, see whether this cannot be corrected by turning the pistons and rod to a new position or by repacking the pump.

Steam Required for Heating Coils

In a heating system using pipe coil radiators supplied with steam at 5 lb. gage pressure, it is estimated that the heating surfaces will radiate 213,000 B.t.u. per hour. What number of pounds of steam will be required and what would be the amount of condensate and its final temperature when returned to the boiler through a 3-in. pipe 300 ft. long? *L. D.*

In condensing, the steam liberates the latent heat of evaporation. The latent heat of evaporation of one pound of steam at the pressure of 5 lb. gage, or 20 lb. per sq.in. absolute, is 960 B.t.u. Therefore to obtain 213,000 B.t.u. per hour would require a supply of 213,000 ÷ 960 = 222 lb. of steam per hour. Upon leaving the radiators the 222 lb. of condensate formed per hour would have the same temperature as the steam, namely, 228 deg. F. The temperature of the water upon arrival at the boiler would depend on the temperature of rooms or other spaces through which the pipe passes and also would depend on whether the pipe is covered and the character of the covering. In conveying 222 lb. of condensate per hour at the initial temperature of 228 deg. F. through 300 ft. of bare 3-in. pipe, the temperature of the water at the discharge end of the line would be reduced to about 15 deg. higher than the average temperature of air through which the pipe extended.

Incorrect Length of Valve Stem

We have an automatic center-crank engine equipped with a Rites inertia governor and piston valve. When the engine is run without load by steam admitted through the bypass valve, exhaust occurs twice for each revolution. But when the main throttle valve is open and the engine is running at full speed, it will exhaust only once for each revolution. What is the cause and what is the remedy? *A. L. C.*

Undoubtedly, the combined adjustment of lengths of the eccentric rod and valve stem is such that the steam port of one end of the cylinder is never opened. When turning the engine over at slow speed with steam admitted only through the bypass valve, the governor is in the extreme position for slow speed, and from the valve traveling too far toward one end, the opening edge of the other end overrides the bridge between the steam port and adjacent exhaust port, and before completion of what should be only an admission stroke of the piston, live steam is temporarily admitted to the exhaust port, and the regular exhaust occurs during the return stroke. When the main throttle valve is opened, speeding up of the engine is accompanied by a position of the governor that reduces the throw of the eccentric with sufficient reduction of valve travel to

prevent the admission edge of the valve overriding the bridge between the steam and exhaust port. Then with steam admitted and exhausted from only one end of the cylinder, there is a single period of exhausting during a revolution of the engine.

The remedy is to adjust the length of the valve stem or eccentric rod, or both, to obtain the same lead for a stroke from either end of the cylinder. This should be done with guidance of steam-engine indicator diagrams. To make an approximate adjustment in case an indicator is not available, block out the governor to the average running position. Make a mark on the crosshead and a corresponding mark on one of the guides when the engine is on each dead center, and open the cylinder pet cocks to determine when either end of the cylinder is supplied with steam. Then place the engine on whichever dead center steam is not admitted when the throttle or bypass is opened, and adjust the eccentric rod and valve stem to such a combined length that steam will be just admitted.

Then turn the engine wheel in the running direction to the position where the valve begins to open to the other end of the cylinder and make a mark on the guide to correspond with the mark that was previously made on the crosshead. Locate a point on the guide halfway between this mark and the dead center mark at the same end of the stroke; turn the engine forward until the mark on the crosshead is even with this mark, and readjust the combined length of eccentric rod and valve stem to obtain the beginning of opening of the valve.

If the operations are performed with care, the leads may thus be made approximately equal. However, if it is desired to make closer adjustments for the opening position of the valve than possible by dependence on admission of steam at the throttle or bypass, with observation of its escape at the cylinder pet cocks, then it would be necessary to open the valve chest and determine the opening positions from actual observations or measurements.

Per Cent of Rating Attained in Operation of Boilers

During 120 hours we operated two boilers each of 3,500 sq.ft. of heating surface, and during 48 hours we operated one boiler of 10,000 sq.ft. of heating surface. The feed-water temperature was 190 deg. F. and the average steam pressure was 150 lb. gage. The total evaporation was 8,254,800 lb. of water. What was the average percentage of ratings at which the boilers were operated? *B. H. H.*

Boilers usually are rated in capacity on the basis of an evaporation, or transfer of heat equivalent to evaporation, of 34½ lb. of water per hour from and at 212 deg. F., per 10 sq.ft. of heating surface, or 3.45 lb. per square foot of heating surface. On this basis the total evaporation should be $[(2 \times 3{,}500 \times 120) + (10{,}000 \times 48)] \times 3.45 = 4{,}554{,}000$ lb. of water from and at 212 deg. F. To evaporate one pound of water from and at 212 deg. F. requires 970.4 B.t.u., and for the evaporation of a pound of water from a feed-water temperature of 190 deg. F. into steam at the pressure of 150 lb. gage, or 165 lb. per sq.in. absolute, requires 1,195 — (190 — 32) = 1,037 B.t.u. Hence for the actual conditions the factor of evaporation would be 1,037 ÷ 970.4 = 1.0686 and the average percentage of rating under which the boilers were operated was 8,254,800 × 1.0686 × 100 ÷ 4,554,000 = 194 per cent.

Construction of Formula for Allowable Pressure for Cylindrical Shell

In the formula for the maximum allowable working pressure for the shell of a boiler or drum, why is the radius used as a divisor? *M. C.*

The complete formula is

$$(1) \qquad p = \frac{TS \times t \times E}{R \times FS}$$

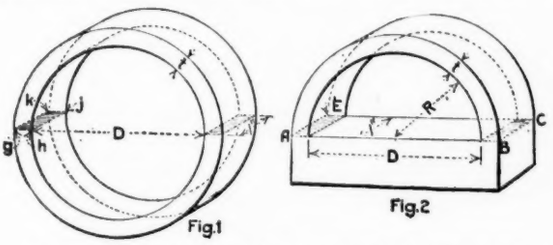
where

p = Maximum allowable working pressure, lb. per sq.in.;
TS = Ultimate tensile strength of material, lb. per sq.in. of cross-section;
t = Minimum thickness of shell plates in the weakest course;
E = Per cent efficiency of longitudinal joint, or of ligaments between tube holes (whichever is the least);
R = Radius (= one-half the inside diameter) of the weakest course of the shell or drum, in.;
FS = The allowed factor of safety.

Calling the diameter D, the formula (1) might be written

$$(2) \qquad p = \frac{TS \times t}{\frac{1}{2} \text{ of } D_1} \times \frac{E}{FS}$$

Neglecting E, the percentage of efficiency, and FS, the factor of safety, would reduce the second member of (2) to



Circumferential resistance of cylindrical shell to internal pressure

$$p = TS \times t \div \tfrac{1}{2} \text{ of } D, \text{ or } p = \frac{TS \times t}{\frac{1}{2}D}$$

Referring to Fig. 1, suppose a cylindrical shell of thickness t and diameter D is 1 in. long, and the internal pressure is p pounds per sq.in. Then neglecting any assistance that may be rendered by the heads or covering of the ends of the shell, the upper half would be held to the lower half by the tensile strength of two diametrically opposite sectional areas like *ghjk*. The total stress to be resisted by the two sectional areas would be the same as though, with the same internal pressure, the upper half were joined to a solid with a plain face *ABCD*, as shown in Fig. 2. In that case the total pressure to be resisted evidently would be $D \times 1 \times p$, or Dp and for each side $\frac{1}{2}Dp$. Therefore for equilibrium $\frac{1}{2}Dp = TS \times t$, or neglecting the efficiency and factor of safety,

$$p = \frac{TS \times t}{\frac{1}{2}D} = \frac{TS \times t}{R}$$

[Correspondents sending us inquiries, should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications, and for the inquiries to receive attention.—Editor.]

Providence Installations Report Success With Pulverized Coal

SO FAR there has been little experimental work done on pulverized coal in New England. For this reason particular interest attaches to the two installations in Providence, Rhode Island, one in the Manchester Street Station of the Narragansett Electric Lighting Co. and the other in the generating station of the United Electric Railways Co. The history of these two installations, with comments on the results obtained, was outlined at a joint meeting of the A.I.E.E. and the A.S.M.E. in the rooms of the Providence Engineering Society on May 27. The meeting was preceded in the afternoon by a demonstration of pulverized-coal burning at the Manchester Street Station.

In outlining the development of the Narragansett installation, E. H. Couch, combustion engineer, expressed satisfaction with the results obtained so far, at the same time calling attention to certain difficulties that had to be overcome. An outline of his remarks follows:

Surface Moisture as a Controlling Factor

Pulverized coal was first employed successfully in boilers about ten years ago. Early tests with Illinois coal spread the impression that coal with as high as 8 per cent moisture could be handled properly without drying. As a general conclusion this is erroneous. Total moisture means little; the surface moisture is the important factor, and this should not exceed 3 per cent at the most. Illinois and some other Western coals have a high inherent moisture, which accounts for the successful operation with 8 per cent total moisture. Pocahontas coal, with an inherent moisture under 2 per cent, cannot be handled properly with a total moisture above 4 or 5 per cent. In general, driers are a necessity.

In 1921 the Narragansett company became interested in pulverized coal. They decided to use the unit system on account of space limitations. Another factor in this choice was the smaller investment and the fact that less power would be consumed in preparation and conveying. A new type of ball mill with air separation was installed. After some experimentation and modification this was brought to the form used today with good results. Burners of the fan-tail type are used in air-cooled furnaces.

Each of the present boilers comprises two of the old stoker-fired 6,000-sq.ft. units. A building column between the two halves was a great source of trouble, but what is believed to be a satisfactory protection for this column has now been developed. Some trouble was experienced with slag which eroded the furnace wall. This was overcome by placing a water screen of 4-in. tubes in front of the back wall (that opposite the burners). The first furnace built had a combustion volume of 6,150 cu.ft., and the second 5,206.

In addition to these, experiments were made with an old oil-burning furnace with a low setting. Practically no change was made beyond installing horizontal coal burners in the wall opposite the oil burners. On account of refractory troubles, these experiments were temporarily abandoned, but they may be continued at a later time, as the results in some ways surpassed those with higher settings. As high as 17 per cent of CO_2 was obtained, and combustion rates as high as 39,000 B.t.u. per cubic foot per hour. The high settings normally operate between 12,000 and 18,000 B.t.u. Efficiencies of 80 per cent were obtained, but the results were erratic and there was a tendency toward incomplete combustion. The flame was much shorter than with the ordinary arrangement of down-shot burners.

With the high settings the efficiency ranged from 80 per cent at 150 per cent of rating to 76 per cent at 250 per cent of rating. The dry-gas loss varied between 12 and 13 per cent over the same range.

Fluctuating Loads Favor Pulverized Fuel

As far as efficiency is concerned, powdered coal shows a considerable improvement over the old short stoker, but not much (at least at steady loads) over improved types. With variable loads there is a big saving in banking losses. In any case the losses due to excess air and to combustible in the ash are reduced. Powdered coal is more flexible and permits closer adjustment of the coal-air ratios. More rapid changes in loads (particularly decreases) are possible. The disadvantages of powdered coal are higher first cost, greater depreciation and slightly greater risk of breakdown. All in all, powdered coal is a slightly better proposition for steady loads and much better for loads that fluctuate widely.

Mr. Couch was followed by W. C. Slade, superintendent of power and lines, United Electric Railways Co., who outlined the developments at the Manchester Street Station.[1] The high points of Mr. Slade's remarks are covered in the following digest.

The fall of oil prices in 1921 led us to debate the relative merits of oil and coal. Influenced largely by the results obtained at Lakeside, we were led to decide in favor of pulverized coal. Another factor in this decision was the uncertainty of future oil prices in view of the limited supply. Still another was the small yard space for tankage. At the same time the possibility of using oil at some future time was kept in mind and provision was made for changing over.

More difficult than the choice between coal and oil was that between stokers and pulverized coal. The decision in favor of pulverized coal was based largely on the higher efficiencies obtainable under test and operating conditions. The differential between test and operating efficiency is only about 3 per cent with pulverized coal as against 5 per cent with stokers. It should be noticed, however, that recent improvements in stokers have cut down the lead of pulverized coal in efficiency. With pulverized coal it is easy to operate with 15 to 20 per cent excess air, and as low as 12 or 15 per cent may be reached.

In this case the problem was to rebuild an old boiler plant to secure the maximum peak-load capacity from a given building volume. Pulverized coal offered the possibility of continuous operation at 300 per cent of rating and operation at 400 per cent for two hours. Eight stoker-fired boilers in two decks were replaced by four pulverized-coal-fired boilers with a considerable increase in developed capacity, in spite of a reduced total heating surface.

The inclined straight-tube, single-pass type of boiler selected seems exceptionally well suited for powdered coal. The heat absorption is good and the response to varying loads is rapid. A stone-cold boiler was put on the line in 50 minutes. Even here, brickwork stresses were the only limitations on the time. An idle but warm boiler was brought to a fair rate of steaming in 20 minutes without difficulty. By closing up all flues and openings, these boilers can be "banked" on the "Thermos-bottle" principle. A boiler so banked at 205 lb. steam pressure still showed 15 lb. pressure after 24 hours. On the other hand, the same boiler can be quickly cooled for repair work by opening all the flues.

Air Cooling a Success

The air cooled setting with 9 in. inner wall is a great help in this rapid cooling. This construction greatly increases the life of the refractories, reducing outages to a minimum. As an experiment three furnaces were laid up with three different types of good brick, using thin fireclay joints of similar composition. All have stood up well. Brick walls with fireclay joints give the needed opportunity for unequal expansion and contraction.

While figured on the basis of a 14,000-B.t.u. coal, this installation will be able to use any Southern coal and any Pennsylvania coal worth shipping to New England; 1,200 tons of Rhode Island anthracite were successfully burned early this year.

The fine ash from the pulverized-coal stack is less objectionable than the clinkers from stokers or the smell from oil. There will probably be no saving in labor. Fewer men are required, but they must be more intelligent. The reduction in banking losses is a big item in this station where the load (electric railway) varies from 1,500 to 21,000 kilowatts.

The four boilers in the present installation have a combined heating sur-

[1] See *Power*, May 1, 1923, for a general plan of the rebuilding this boiler room for powdered coal.

face of 50,000 sq.ft. With a continuous rating of 300 per cent and two-hour rating of 400 per cent this represents more actual capacity than the 80,000 sq.ft. total for the original eight stoker-fired boilers.

Each boiler has 10,000 cu.ft. of combustion space, the furnace being 24 ft. 8 in. wide, 25 ft. 8 in. high from water screen and 17 ft. 3 in. deep at the widest point.

Tests have recently been made, but the data have not been worked up. At 150 per cent of rating the flue gases leave the boiler around 445 deg. and the economizer around 230 deg. The corresponding figures at 311 per cent of rating are 560 deg. and 310 deg. The draft loss at 200 per cent rating is about 0.5 in. through the boiler and 0.5 through the economizer. The average CO_2 is between 15 and 16 per cent, although 17 per cent has been obtained.

The total cost of rebuilding the boiler room will be around $800,000. Each boiler erected, without its setting, costs about $37,000. The setting, steel casing, refractory and insulating brick in place bring this to $65,000. Economizers, fans, breechings and flues add $31,000 and the pulverized coal equipment immediately chargeable to the given boiler another $10,000, making the total cost of each "unit" $106,000. The remaining pulverized-coal equipment, piping, building changes, etc., bring the total to $200,000 per boiler.

It is expected that the boiler efficiency (without economizer) will reach 80 per cent for all ratings between 100 and 300 per cent.

The following officers for the Providence Section of the A.S.M.E. were elected for 1924: Chairman, Robert L. Blanding; secretary, Francis A. Chiffelle.

Station Piping and Fittings at High Pressures and Temperatures

THE report on station piping, of the Prime Movers Committee of the National Electric Light Association, issued April, 1924, includes tentative specifications for flanges and fittings issued by the American Engineering Standards Committee, with the request for any suggestions that may be offered. Specifications of flange dimensions for higher pressures and temperatures were published in *Power*, Dec. 4, 1923, and March 18, 1924.

The tentative specifications of carbon-steel castings for valves, flanges and fittings, which are A.S.T.M. specifications, serial designation No. A-87-22-T, for Class B steel, which is modified by the A.E.S.C. Committee, contains information concerning patterns and manufacture.

The castings shall conform to a chemical composition of carbon 0.25 to 0.35 per cent; manganese, 0.85 per cent maximum; phosphorus, 0.05 per cent maximum, and sulphur, 0.05 per cent maximum, which shall be made from drillings taken at least ¼-in. beneath the surface of a test ingot obtained during the pouring of the melt. This shall be reported to the purchaser. The purchaser may also make an analysis from a casting representing each melt, as a check. This composition shall conform to the requirements just specified. Drillings for analysis shall be taken not less than ¼-in. beneath the surface, and in such a manner as not to impair the usefulness of a casting.

Further specifications deal with workmanship, finish and the freedom of the purchaser's inspector to have free entry at all times while the work on the contract of the purchaser is being performed. Conditions in regard to rejection of material by the purchaser and rehearing are also included.

Tentative specifications for bolting material as included A.S.T.M. specifications, serial designation No. A-18-21, Class K, L or M, modified, are herein partly quoted.

(3) Heat Treatment—"Steel for bolts shall be quenched from a temperature above its upper critical range and, finally, they should be uniformly reheated to the proper temperatures for tempering or 'drawing back,' so that the steel may attain its maximum tough hardness, after which it is to conform to the following physical properties: yield point—65,000 lb. per square inch minimum, elongation in 2 in.—16 per cent minimum, reduction of area—50 per cent minimum. The minimum ultimate strength of this material shall be 95,000 lb. per square inch.

(4) Tests—"One tension test shall be made from each lot of 100 pieces or less, or from quench or drawback charge of either bars or bolts. If more than one melt is represented in any quench or drawback charge, a test must be made from each melt.

"The yield point shall be determined by the drop of the beam of the testing machine, or by physical measurement, and shall conform to the requirements specified in Section 3.

"Bolts shall be selected at random by the purchaser's representative for hardness test. The number of bolts so selected is not to exceed 5 per cent of the total number of bolts represented. In case of failure of any bolts in test lot to test within 5 per cent over the maximum or under the minimum hardness limits specified, the purchaser may require that all bolts represented be tested.

"The maximum and minimum Brinell hardness limits respectively should be 300 and 200; this assumes the corresponding schlerescope hardness to be 47 and 30, and the corresponding Rockwell hardness to be 37 and 21.

"The maximum and minimum Brinell hardness limits specified, 300 and 200 respectively, correspond approximately to 145,000 lb. and 95,000 lb. ultimate tensile strength per sq.in. and 115,000 lb. maximum and 65,000 lb. per sq.in. minimum yield point.

(5) Retests—"(a) If any test specimen shows defective machining, it may be discarded and another specimen substituted.

"(b) If the percentage of the elongation of any test specimen is less than that specified in Section 3, and any part of the fracture is more than ¾ in. as indicated by the scribe scratch-marked on the specimen before testing, a retest shall be allowed. If the results of the physical tests of any test lot of bolt studs do not conform to the requirements specified, the manufacturer may retest such a lot one or more times and retests shall be made in accordance with Section 3.

Chemical Properties and Tests

(6) Chemical Composition—"The steel shall conform to the following requirements as to chemical composition: phosphorous, 0.04 per cent maximum; sulphur, 0.05 per cent minimum.

(7) Check Analysis—"An analysis may be made by the purchaser from bolt material representing each drawback charge or melt. The chemical composition thus determined shall conform to the requirements specified in Section 6. Drillings for analysis may be taken from full size bolt, or from the rods from which bolts are made, or from turnings from test specimen.

Tentative Specifications for Allowable Stresses in Valves and Fittings for Bolts

"The maximum allowable working fibre stress in:

Cast steel in bodies of valves and fittings, 7,000 lb. per sq.in.

Bolting material for line or end flanges on pipe, valves and fittings, 7,000 lb. per sq.in.

Bolting material other than end flanges, 9,000 lb. per sq.in.

RATINGS RECOMMENDED IN POUNDS PER SQUARE INCH

Working Steam Pressure Rating at 750° F. Pounds per Sq.In.	Working Non-Shock Hydraulic Rating at 450° F. Such as Boiler Feed Lines Pounds per Sq.In.	Working Non-Shock Hydraulic Rating at Normal Temperatures Pounds per Sq.In.	Hydrostatic Shell Test Max. 100°F. Pounds per Sq.In.
250	300	500	750
400	480	750	1,000
600	720	1,000	1,500
900	1,080	1,500	2,000

"All tests shall be made hydrostatically with cold water not to exceed 100 deg. F. A fibre stress of 16,000 lb. per sq. in. during test shall be allowed on cylindrical sections, but in no case must this fibre stress be exceeded.

Physical Properties and Tests

(7) Tension Tests—"(a) Yield point—36,000 lb. per square inch minimum, elongation in 2 in.—22 per cent minimum, reduction of area—30 per cent minimum, the minimum ultimate strength shall be 70,000 lb. per square inch.

"(b) The yield point shall be determined by the drop of the beam and at a cross-head speed not to exceed ⅜ in. per minute. The tensile strength shall be determined at a speed not to exceed 1½ in. per minute.

(8) Test Specimens—"Sufficient test bars from which test specimens required in Section 7 may be selected shall be cast on or with the castings. Test coupons shall remain attached to the castings throughout the annealing and, in the case of test blocks, they are

to be either annealed or normalized with the castings they represent. Tension test specimens shall conform to the dimensions shown in the figure. The ends shall be not less than ¾ in. in diameter and of a length and form to fit the holders of the testing machine in such a way that the load shall be axial.

(9) Number of Tests—"(a) One tension test shall be made from each annealing charge. If more than one melt is represented in an annealing charge, one tension test shall be made from each melt.

"(b) If any test specimen shows defective machining or develops flaws, it may be discarded; in which case the manufacturer and the purchaser or his representative shall agree upon the selection of another specimen in its stead.

"(c) If the percentage of elongation of any tension test specimen is less than that specified in Section 7 (a) and any part of the fracture is more than ¾ in. from the center of the gauge length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

(10) Retests—"If the results of the physical tests of any test lot do not conform to the requirements specified, the manufacturer may re-anneal such lot not more than twice, and retests shall be as specified in Section 7.

(11) Special Tests—"Cold bend tests, Brinnell hardness tests, impact tests, endurance tests, photo-micrographs and tests at elevated temperatures are not included in the scope of this specification."

Remarks on steam-line bolting are included in the main report of the convention at Atlantic City on May 14-17.

The remainder of the report includes manufacturers' statements of steel for use in valves, research in regard to the effect of cutting threads, strength of nuts vs. that of studs under tension, etc.

Methods of Transformer Cooling

Transformer development during recent years has involved the production of self-cooled transformers in some very large sizes. Water for cooling is frequently expensive, or hard to get, or needs to be recooled by cooling tower, spray pond or the like, and in cold climates there is always the possibility of freezing of the circulating system. The circulating water may be scale-forming to a sufficient extent to cause trouble without prior treatment, hence this development in self-cooled transformers, for even the very large sizes.

Space requirement and general bulkiness, proportion of investment represented by the radiators and their contained oil, and possible fire hazard through the presence of large quantities of oil in tank and radiators are beginning to lead toward research into other methods of cooling, notably circulating oil through radiators of the automobile type, air being blown through these radiators by auxiliary power-driven blowers or fans. The results of experiments along these lines made by the Southern California Edison Co., according to the N.E.L.A. Electrical apparatus Committee's report, have been encouraging enough to warrant an appropriation for a trial installation embodying this method of cooling.

An unusual method of transformer cooling is used by the Southern California Edison Company at one of its substations in a congested part of the city where ground space is at a premium. The building is several stories high and the transformers are in the basement; but the radiators used for cooling are on the roof, so that advantage may be taken of the breeze blowing in from the ocean. This station has been in operation for several months, and the method of transformer cooling has been sufficiently satisfactory to justify the installation of another transformer bank, using the same method of cooling.

Test on an Opposed-Piston Diesel

A series of test-bed trials have been conducted by Engineer-Commander Hawks on a 2,700-hp. Camellaird-Fullogar engine built by Palmer Works. As reported by *Engineering*, the object of the trials was to determine the fuel consumption per brake horsepower-hour at various powers. Tests of two or three hours were run, during each of which the power and revolutions were arranged to follow the requirements of the propeller law as closely as possible. The power was absorbed by a Heenan & Froude dynamometer. At the beginning of each test fuel was drawn from one tank and at the end of 15 minutes this tank was shut off and the second connected to the suction pipe, and an accurate record of the consumption every 15 minutes was thus insured. All the instruments were carefully calibrated before the tests. Persian fuel oil was used, and samples were taken during each trial and analyzed and the calorific value determined.

AVERAGES OF TRIAL RESULTS

Load	Quarter	Half	Three quarters	Full
Duration of test, hr.	2	3	3	3
Revs. per minute	57.7	70.0	76.9	85.4
B.Hp.	815	1,484	2,115	2,765
Fuel per lb. per b.hp.-hr.	0.463	0.422	0.404	0.405

The main engine drives the circulating pump for jackets and piston cooling, the forced lubrication pump and the scavenging pump, which absorb in all about 150 b.hp. The results must be viewed in the light that no allowance was made in them for this, and that the oil used was not of the highest calorific value obtainable.

The brake thermal efficiency of the engine, taking the lower calorific value of the fuel as 17,730 B.t.u. per pound, was found to be 35 per cent for the mean results of the full power trial. The exhaust was quite colorless during all but the quarter-load test, when a slight haze was produced. The engine was under close observation during the whole period of the trials, and the report shows that it ran smoothly and well without a stoppage of any kind. Further tests are, we understand, to be undertaken by the Marine Oil Engine Trials Committee of the Institution of Mechanical Engineers.

Generator Power-Factor Rating

Considerable operating difficulties have been experienced in the past on 60-cycle systems because in many cases the system power factor was considerably below the power-factor rating of the principal turbo-generators, and there has been a decided tendency to demand generators of lower power-factor rating. The improvement of system power factor is much to be desired, and strong efforts are being made and should be greatly encouraged in this direction, but it will probably be many years before the results will warrant an increase in rating over that now in general demand.

The following unanimous action was taken by the N.E.L.A. Electrical Apparatus Committee after considerable discussion of a suggestion made by a subcommittee of the Association of Edison Electric Illuminating Companies to both the Prime Movers and Electrical Apparatus Committees:

It is the sense of the Electrical Apparatus Committee—

1. That the Prime Movers Committee and the Edison Association Committee should arrange for any desired overload capacity in the steam turbine, but not tie it up with generator power-factor rating.

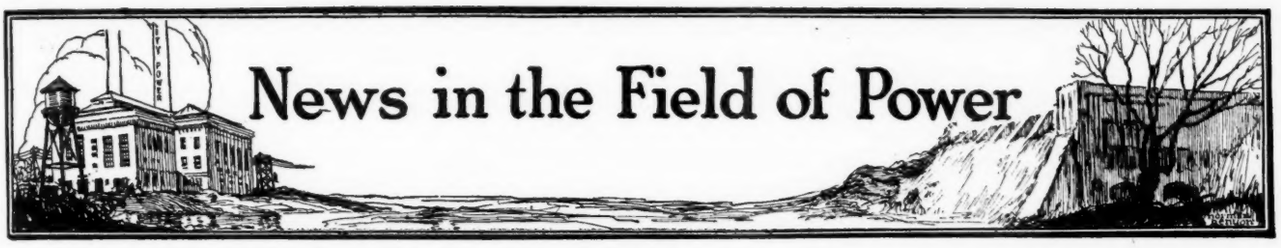
2. That standard 60-cycle generators should be rated at 80 per cent power factor, which would then be entirely capable of being used at higher power factors within the kva. rated capacity up to the maximum available kw. of the turbine.

3. That standard 25-cycle generators should be rated at 100 per cent power factor, except where and when lower power factors are desired that they should be so specified.

Houston Ship Channel Plant Nearing Completion

Ten miles from Houston, Tex., on the ship channel, the first section of a new oil-burning generating station, on which construction was started last August, is rapidly nearing completion and is expected to be in operation by July. It will become the base-load plant of the Houston Lighting & Power Company.

The first section will contain two 20,000-kw. 11,000-volt turbo-generators and two rows of three 20,000-sq.ft. oil-fired boilers. Concrete stacks, 362 ft. high, built to withstand high wind pressures, will serve the furnaces, each being sufficient for six boilers. Air preheaters are being installed. Feed-water heating and complete heat balance are obtained by bleeding the turbines at the third, seventh and eleventh stages. A house-turbine generator will float on the line, all auxiliaries being motor-driven. Owing to the sluggish flow of water in the ship channel, spray ponds will have to be used with the second section for circulating water, as the water from the channel reaches 91 deg. in the summer, making it necessary to resort to artificial cooling of the water if an efficient vacuum is to be maintained.



No Reliable Figures Available on Coal Storage

If Cold Weather Comes Early Prices Will Soar—Stock Report Could Be Compiled for $20,000 Yearly

SOME exception has been taken to 65,000,000 tons as the amount of coal in storage on April 1. That figure was arrived at only after due study had been given such information as throws light on the extent of storage. The fact, however, that the figure was questioned prompted an inquiry of various coal specialists as to their estimates of storage on April 1. These estimates varied from 40,000,000 tons to 75,000,000 tons. The inquiry also developed that the men who are specializing in coal recognize that one of the very important elements in the present situation is the amount of storage.

While the reference to the 65,000,000-ton figure was made only incidentally in an effort to reflect opinion to the effect that consumers would be well advised to buy coal now, when it is selling below cost, and save their stockpiles against the time when transportation may be scarce and coal prices higher, this incident has emphasized the deplorable lack of figures showing current consumption of coal. Not only are such figures necessary for the intelligent production and purchase of coal, but they would furnish one of the most valuable business barometers just at this time, when there is such difference of opinion as to the extent industry is slackening its pace.

It would cost only $20,000 a year for the United States Geological Survey and the Bureau of the Census, possessing as they do going statistical divisions handling coal exclusively, to compile a stock report quarterly.

A warning comes from an important official source that, in calculating the extent to which reserves of coal can be depleted, consideration must be given to the possibilities of weather conditions which will interfere with transportation efficiency. For several years the winters have been open ones. The railroads have been able to operate during the period of grain movement and other heavy demands for transportation, without having to combat much unfavorable weather. There always is the chance that the next winter may set in early. Not only would that interfere with the efficiency of transportation, but the early advent of cold weather would accentuate the autumn peak, with the resulting price increases and the possibility that many plants might be unable to secure the supplies necessary to continue operation. That official expresses the opinion that the provident consumer buys in a buyers' market and does not put himself in the position where he must buy in a sellers' market.

Plant Equipment Exports First Three Months, 1924

According to the Bureau of Foreign and Domestic Commerce there were exported from the United States during January, February and March, 1924, 18 steam turbines with a value of $183,-851; 114 stationary steam engines at $136,409; 18 mechanical-drive turbines at $183,851; boilers of 148,158 sq.ft. of heating surface at $393,838; 137 Diesel and semi-Diesel engines at $91,236; 98 waterwheels and turbines at $22,356 under 300 hp., and 7 at $78,143 over 300 horsepower.

New Plant for Holtwood, Pa., Planned

Interests identified with the Pennsylvania Water & Power Co. have formed a new company capitalized at $3,500,-000 for the purpose of building another power plant at Holtwood, Pa. The new plant will adjoin the existing plant of the Pennsylvania Water & Power Co. and will be tied in with lines serving the Consolidated Gas, Electric Light & Power Co. of Baltimore. It will go into operation early in the spring of 1925 and will have an ultimate capacity of 100,000 kw. with an initial installation of 20,000 kw. Contracts for two units have been placed in New York and work will begin at once.

French Interested in Hydro Developments

Recently issued statistics say that of the 9,000,000 maximum hydro-electric horsepower available in France nearly 2,000,000 hp. has already been harnessed, and it is expected that by the end of the year the total will have reached 3,000,000 hp., with an estimated saving of coal amounting to 18,-000,000 tons a year. More than two hundred applications for water-power development are on file with the Public Works Department, which will add 1,500,000 hp. to the present output, and in the Maritime Alps alone four sites are under development whose total production will be 500,000 hp. Twenty years ago, the statistics say, only 200,-000 hp. was produced in France from hydro-electric plants. It is predicted that the output will reach 4,000,000 hp. within the present decade.

Italy's Superpower Development

With the completion of new plants under construction in the Sila Mountains, Italy will be connected from the Alps to Sicily by a distributing system to which most of the power stations will be able to furnish current, from the Adamello Co. in the Alps and the Terni Co. in central Italy to the Sila in Calabria and the Generale Elettrica in Sicily.

There is another combination headed by the Edison Co., with which the Negri Co. is now affiliated. This includes many power companies operating in Lombardy, Piedmont, Liguria, and Emilia, and represents about 1,000,000,000 lire of capital, according to *Commerce Reports.*

Tallapoosa River Project Licensed

Pursuant to the preliminary permit issued Jan. 27, 1923, the Federal Power Commission has authorized a license in favor of the Alabama Interstate Power Co. for its Tallapoosa River development. Failure of the Alabama Public Service Commission to grant an amendment in the power company's certificate of convenience and necessity made it necessary to insert in the license a condition whereby the state rights would be perfected before work is begun on two of the dams covered by the license.

The license covers the five sites above the Cherokee Bluffs unit which are necessary to make the fullest practicable utilization of the power resources of the stream. Their combined installed capacity will be 114,000 horsepower.

The original plan of the company called for three instead of five dams, and the certificate of convenience and necessity issued by the Public Service Commission of Alabama was worded so as to cover only the three dams. When detailed surveys were made, it was found necessary to limit the height of certain of the dams and to interpolate two small ones. It is these two small dams which are not covered by the rights the company holds from the state.

The reluctance of the Alabama Public Service Commission to grant any additional rights on the Tallapoosa is thought to be due to the fact that there is a new realization of the importance of this Tallapoosa storage in connection with the operation of the Muscle Shoals project.

Wants World's Fair in United States in 1930

A world's fair in the United States in 1930 with a Congressional commission to determine its site, would be provided for under a bill prepared by Representative Bloom, of New York, recently, according to press reports. Mr. Bloom plans to visit the British Empire Exhibition at Wembley, England, for first-hand information after Congress adjourns.

Overseas Export of Coal Increases During April

Government reports state that overseas exports of bituminous coal from the United States in April amounted to 396,428 long tons, a large increase over the 285,114 tons during March. Total bituminous exports during April were 942,638 tons against 1,111,752 in March. The amount shipped to Canada,, our principal customer, was much lower than during the previous months of 1924, causing the total exports to fall. The demand from Italy still continues, 109,433 tons being sent to that country in April against 43,702 tons in March; while France took 78,551 tons, by far the largest quantity shipped during the current year. Exports to both countries during the month were well over the monthly average for 1923.

Tide Power Project Needs Canadian Cooperation

The Federal Power Commission has asked the State Department to suggest to the Canadian government that it joins with the United States in referring to the International Joint Commission for investigation, report and recommendation, the application of Dexter P. Cooper, for a preliminary permit covering tidal power project in the Bay of Fundy. Mr. Cooper, whose address is 217 Summers St., Buffalo, N. Y., proposes to erect a series of dams connecting the islands which separate Passamaquoddy Bay and Head Harbor from the Bay of Fundy, thereby creating two pools, between which he proposes to erect a power house of large capacity, at which he plans to develop continuous power from the pool which will be filled by the tide and by water from the St. Croix River.

The engineers of the Federal Power Commission have some question as to the feasibility of the project, but its magnitude and the public interest that is attached to the possibilities of developing power by the use of tides seems to justify the investigation. If constructed the project will be located partly in the Dominion of Canada. This requires rights from the two governments. This brings the project distinctly within the jurisdiction of the International Joint Commission.

Topographic Maps Advocated by Engineers

The committee on Interstate and Foreign Commerce of the House of Representatives did an unusual thing on May 27, when, immediately following a hearing on the Temple bill, which provides for the topographic program necessary to the completion of the map of the United States, the committee met in executive session and ordered the bill reported favorably.

The need of complete topographic maps was presented to the committee by E. B. Mathews, the president of the association of State Geologists. The need for topographic maps in connection with transportation was pointed out by A. N. Johnson, chairman of the Advisory Board on Highway Research of the National Research Council. S. H. McCrory, the president of the American Society of Agricultural Engineers, and C. G. Elliot, of the Illinois Engineering Society, told of the use of maps in connection with flood control and agricultural and reclamation development. George H. Ashley, the State Geologist of Pennsylvania, told of the need of maps in connection with mining and water-power development. L. W. Wallace, the executive secretary of American Engineering Council, acquainted the committee with the unanimous demand among engineers generally, for a more adequate program of topographic mapping. William Bowie appeared and urged the passage of the bill as representative of the American Society of Civil Engineers. A. C. Olliphant testified on behalf of American Engineering Council.

The committee called C. H. Birdseye, chief topographer of the Geological Survey, to act as its advisor. Colonel Birdseye indorsed the statements that had been made by these various witnesses and pointed out the practical uses made of topographic maps.

The bill now is on the House calendar, but cannot be reached at this session of Congress, if adjournment is effected on June 7 as it planned. By being reported at this time, however, the bill will be in a preferential place on the calendar at the December session.

Attorney-General Hopeful About Trade Statistics

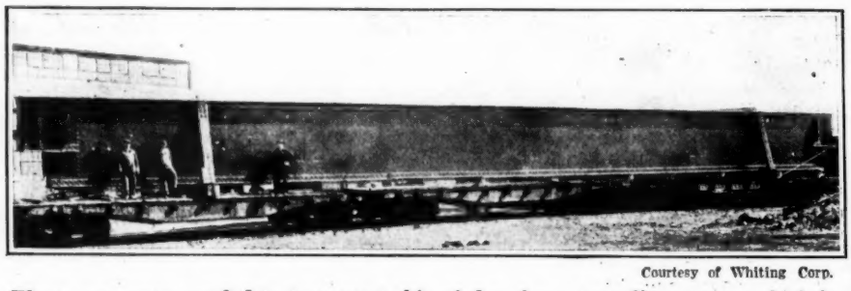
THOSE most concerned as to the trade associations' statistical situation are very much encouraged by the attitude of the new Attorney-General. Mr. Stone has stated publicly that he is very hopeful of a satisfactory solution of the matter. There is reason to believe that he recognizes that the policy of the Department toward these figures has not been constructive. At the same time the Attorney-General is not in a position, it is believed, to discuss his views in detail at this time because of their possible application to pending cases.

It now seems probable that a test case may be brought, although that step will not be taken in the immediate future. In the meantime consideration is being given the expediting of certain of the pending cases in which certain important trade association questions are involved.

Maine's Aloof Attitude in Regard to Power Censured

Speaking before a recent meeting of the Maine Association of Engineers at Portland, Edward G. Lee, of Auburn, condemned the non-exportation policy of the state in emphatic terms and declared that Maine should become a part of the territory to be embraced in the "superpower" interconnected project for the North Atlantic seaboard states. Mr. Lee said among other things:

"I feel perfectly safe in assuming that with the load centers of the State of Maine tied into a large-capacity, high-tension transmission line connected with the superpower system as proposed, the price of power available from that line would be not over three-fourths of the price of the best hydro-electric power now undeveloped in the state if delivered to those same load centers. By our own wishes we have been left out of the consideration in the superpower system, and we have thereby cut ourselves off from the most sure source of relatively cheap future power until we change our position. We do have some water powers left undeveloped in this state and they are unquestionably of some value, but they would also unquestionably be of more value to us all as well as to others if they were tied in a large system like the superpower system. Such tying together of plants makes it possible to develop the water powers very much more efficiently, in larger volumes and therefore at an appreciably lower cost. The chance of our attracting new industries to the State of Maine would be much better if our powers here were so tied in than would be possible by the present independent systems or even if all of the present companies in the state were tied together."



Courtesy of Whiting Corp.

Three cars were needed to transport this girder, for a traveling crane, which is to be used in the turbine room of the Crawford Ave. Station, Chicago, Ill.

Bear River Power House Part of Dam

At a total cost of approximately $3,000,000 the Utah Power & Light Co. is adding 20,000 hp. to its hydro-electric system by the construction of a huge dam on the Bear River, near Alexander, Idaho. Preliminary work was undertaken in August, 1922, and now the development is nearing completion. The dam will be 80 ft. high and 518 ft. long across the top. The power house is being built against the downstream face of the dam, forming a part of it.

New Equipment for Richmond Station

The Philadelphia Electric Co. has recently ordered for its new Richmond station, two G.E. 50,000-kw. 1,800-r.p.m. turbines with direct-connected exciter, to operate at 375-lb. gage, 233 deg. F. superheat, one-inch absolute back pressure. The generators are rated 50,000 kw., 80 per cent power factor, 62,500 kva., 1,800 r.p.m., 13,800 volts. The exciters are rated 250 kw., 1,800 r.p.m., 250 volts shunt wound. These machines are to be delivered in July and September, 1925, for operation in the new station, which is to have an ultimate capacity of 600,000 kw.

Iowa Association, N.A.S.E. Program

The Iowa Association of the N.A.S.E. will have papers of interest to *Power* readers at its annual meeting, which is to be held at Sioux City, June 10-14 as follows:

Illustrated lecture "The Story of Asbestos," by W. P. Lyons, Johns Manville, Inc.; "Variables Involved in the Analysis of Fuel," by S. H. Viall, Wilmington & Franklin Coal Corp.; "Tom Marsh Butts In on Pulverized Fuel," by T. A. Marsh, Combustion Engineering Corp.; "Refrigeration From a Practical Engineer's Standpoint," by Frank Anderson, York-Allan Ice Machine Co.

Upper Mississippi River Developments

St. Cloud, Minn., expects in the near future to be the center of the most important hydro-electric projects on the upper Mississippi River. Three new dams are projected and the one now existing at St. Cloud will be rebuilt. This will make six dams in the 50-mile stretch from Elk River to Little Falls —at Elk River, St. Cloud, Sartell, Rice, Royalton and Little Falls respectively. The average production of these dams will be from 40,000 hp. to 45,000 hp. The Pike Rapids dam will have a 45-ft. head and will cost about $3,000,000. At Rice plans call for a dam with a 25-ft. head and an investment of $2,000,000. Development of plans for the Clearwater dam already are under way.

The coal output for Yugoslavia for 1922 was the largest since the formation of the Kingdom, as seen from the following figures of production: 2,497,394 metric tons in 1919; 3,224,324 tons in 1920; 3,067,021 tons in 1921; 3,778,308 tons in 1922.

Water-Power Investigations Made by Geological Survey

During the season of 1923 engineers of the Geological Survey surveyed 1,150 miles of rivers, mapped 46 dam sites and 21 reservoir sites and made records of stream flow at 1,600 gaging stations. Geologists examined the geologic structure at more than 50 proposed dam sites. The data gathered were analyzed and incorporated in reports on stream flow, water power and irrigation. The estimated potential power available 50 per cent of the time on the streams surveyed amounts to 2,500,000 hp.

About 200 miles of the Colorado River were mapped 24 dam sites surveyed and a geologic examination was made at each site. In Oregon 300 miles of Rogue River and its tributaries, 13 dam sites and 5 reservoir sites were mapped. The Klamath River was mapped for 100 miles and seven dam sites and two small reservoir sites were surveyed. The western tributaries of South Platte River from Denver to the Colorado-Wyoming line were mapped, as well as the Sweetwater and Encampment Rivers in Wyoming. In Colorado and Wyoming 460 miles of river surveys were made, 14 reservoir and 12 dam sites were mapped. Several small streams in the Uinta River basin in Utah were mapped. Geologic examinations were made of numerous dam sites in connection with the Columbia River basin. In Montana a survey was made of a dam and reservoir site on South Fork on Flathead River near Kalispell, the use of which would increase the potential power of Flathead and Clark Fork Rivers nearly 300,000 hp.

Agree to Make Muscle Shoals Unfinished Business December 4.

After months of study and controversy the Senate Agriculture Committee has finally reported a majority and a minority report on Muscle Shoals to the Senate.

The majority report, called the Norris bill, advocates government ownership and supervision of the property, denounces the Ford offer, and criticizes the Administration and Henry Ford personally in vigorous manner. This bill is reported as being agreeable to the power companies.

The minority report indorses the Ford offer and condemns government ownership and operation.

The Senate on June 5 reached an agreement to make Muscle Shoals unfinished business to be taken up at the December session of Congress.

Water-Power Projects

Parahyba River, South America, Project Nearly Finished—What is said to be the largest hydro-electric power development in South America, on the Parahyba River, described in *Power*, Oct. 11, 1921, page 548, is nearing completion.

Toronto, Ont.—It was stated in the Ontario Legislature recently that the total amount spent to date on the Queenston-Chippawa hydro-electric construction work was $70,399,166, and that 1,000 miles of rural primary transmission lines had been laid.

Water Power for Ireland. — Recent notice of intention to introduce into the Dail private bills for the incorporation of companies to exploit the hydro-electric resources of the Liffey marks the revival of projects contemplated some time ago on this river, according to *Commerce Reports*.

Ceylon Project. — A hydro-electric project involving an expenditure of approximately 10,000,000 rupees, will be undertaken in Ceylon in the near future. It is planned to utilize the Laxapana Waterfalls in the central mountain range of Ceylon according to Commerce *Reports*.

Spain Plans Irrigation and Hydro-Electric Development.—A development scheme is being considered by officials of Murcia, Alicante and Cartagena, Spain. The project includes the building of a dam and irrigation ditches. The water is to be used for hydro-electric power purposes, irrigation developments, and water supply for these cities. It is also reported that there are good prospects of the Spanish government making material guarantees to assist the venture.

Personal Mention

Robert H. Karl, supervising engineer for Anheuser-Busch, Inc., for the last sixteen years, has resigned this position to accept a position as Commissioner of Smoke Regulation for the City of St. Louis.

C. A. Clendening, operating superintendent of the Winnipeg (Canada) Hydro-Electric System, has been appointed commissioner of the Manitoba Hydro-Electric Commission in succession to J. Rocchetti who has resigned.

George Otis Smith, director of the Geological Survey, has been designated by Secretary of the Interior Work, to represent him as an official delegate to the World Power Conference, to be held in Wembley, London, June 30-July 12.

Dean Mortimer E. Cooley, of the Engineering School of the University of Michigan and past-president of the American Engineering Council, is a candidate for the Democratic nomination for Senator from the State of Michigan, to succeed Senator James E. Couzens.

M. D. Church has been appointed general manager of the Moore Steam Turbine Corp., Wellsville, N. Y., as of June 1. Mr. Church has spent practically his entire life in steam-turbine work. Graduated from Syracuse University in 1906, he was later in the employ of the Kerr Turbine Co. for six years, during which time he served as assistant chief engineer and factory superintendent under the late J. L. Moore. For the last nine years Mr.

Church has acted as chief engineer for the Terry Steam Turbine Co. He is exceptionally well known in engineering circles. As a member of the A. S. M. E., he is serving on the Power Test Code Committee of the Steam Turbine Division. He has the best wishes of the engineering fraternity in this larger field of endeavor upon which he has entered.

C. G. Beckwith, who has been performing the dual duties of commission and plant superintendent of the municipal electric-light plant at Cleveland for some time, has resumed his duties as plant superintendent, and Fred L. Mowry has been appointed commissioner of the plant.

Obituary

William J. Baldwin, of Brooklyn, N. Y., died unexpectedly on May 7. This will be learned with sincere regret by all who were privileged to know him. A native of Ireland, born June 14, 1844, Mr. Baldwin spent the major part of his life in this country, where he received his education and training. As a naval constructor he did a great deal for the government during the Civil War and later the Brazilian government employed him in the construction of naval vessels. Many notable buildings were engineered by him, and he laid the first telephone from New York to Brooklyn. He was a member of the Committee of the A.S.M.E., in 1886, when the Briggs Standard for Pipes and Pipe Threads was recommended and adopted as the U. S. Standard, since sometimes known as the American Standard. Mr. Baldwin was also a member of an international commission which attempted to produce an acceptable "International Standard for Pipe Threads," from 1906 to 1914, when the World War interrupted his work temporarily. Other societies of which he was a member were the A. S. H. & V. E., A. S. C. E. and American Institute of Architects. *Engineering Record* had him as an associate editor for a time, and he was also a professor of thermal engineering at the Polytechnic Institute of Brooklyn. Several books written by him on heating and ventilation are widely used.

Business Notes

Dean Brothers Co., manufacturer of pumping machinery has moved its office to 149 Broadway, New York City.

The Chicago Pneumatic Tool Co., Chicago, Ill., announces the removal of its Los Angeles sales and service headquarters from 307 East Third St. to its new building at 655 Santa Fe Ave.

The Economy Fuse & Manufacturing Co., on June 1 removed its Chicago district sales office from 536 Transportation Bldg. to larger quarters at 512 West Jackson Boulevard.

The Industrial Works, Bay City, Mich., has appointed C. D. Price district sales manager of the St. Louis district, with headquarters in the Railway Exchange Building.

Coming Conventions

American Association of Engineers. C. E. Drayer, 63 East Adams St., Chicago, Ill. Annual meeting at San Francisco, June 11-13.

American Boiler Manufacturers' Association. H. N. Covell, 191 Dikeman St., Brooklyn, N. Y. Annual meeting at the "Homestead," Hot Springs, Va. June 9-11.

American Institute of Electrical Engineers. F. L. Hutchinson, 33 West 39th St., New York City. Annual convention, Edgewater Beach, Chicago, Ill., June 23-27.

American Order of Steam Engineers. W. S. Wetzler, 753 North 44th St., Philadelphia, Pa. Annual meeting at Moose Hall, 1314 North Broad St., Philadelphia, Pa., June 9-13.

American Society of Civil Engineers. J. H. Dunlap, 33 West 39th St., New York City. Convention, Pasadena, Calif., June 18-21.

American Society of Heating and Ventilating Engineers. F. C. Houghten, 29 West 39th St., New York City. Semi-annual meeting at Kansas City, Mo., June 10-12.

American Society for Testing Materials. C. L. Warwick, University of Pennsylvania, Philadelphia, Pa. Annual meeting, Chalfonte-Haddon Hall, Atlantic City, N. J., June 23-28.

Association of Municipal Electrical Utilities of Ontario. S. R. A. Clement, 190 University Ave., Toronto, Ont. Meeting at Niagara Falls, June 26-28.

Canadian Association of Stationary Engineers. Gordon C. Keith, 51 Wellington St., West Toronto, Ont. Annual meeting, St. Thomas, Ont., June 24-26.

Fourth International Congress of Refrigerating Engineers. J. Raymond, Weavers' Hall, 22 Basinghall St., London, E.C. 2. Held under the auspices of the International Institute of Refrigeration, at the Ministry of Labour, London, Whitehall, S.W. 1, June 16 to 21.

National Association of Stationary Engineers. Fred W. Raven, 417 South Dearborn St., Chicago, Ill. Annual convention and exhibition at Hotel Pantlind, Grand Rapids, Mich., Sept. 8-13. Annual conventions and exhibitions of the state associations are scheduled as follows: **Iowa Association** at Sioux City, June 10-14. Abner Davis, 16 Waterhouse Block, Cedar Rapids, Iowa. **New York State** at Niagara Falls, June 13-14. William Adelyotte, Shredded Wheat Co., Niagara Falls. **Ohio Association** at Akron, June 19-21. T. S. Garrett, 2622 East Second St., Dayton, Ohio. **Connecticut Association** at Bridgeport. June 27-28. George F. Klopfer, 30 East Pearl St., New Haven, Conn. **New England States Association** at Cambridge, Mass., July 10-12. Freeman L. Tyler, 32 Briggs St., Taunton, Mass. **Wisconsin Association** at Fond du Lac, July 24-26. Vincent Todd, 25 Fourteenth St., Fond du Lac. **Minnesota Association** at Faribault, Minn., July 31, Aug. 1-2. C. A. Nelson, 800 22nd Ave., N. E. Minneapolis. **Michigan Association** at Grand Rapids, Sept. 8. Wm. H. Yeomans, 209 Plainfield Ave., Grand Rapids.

National District Heating Association, D. L. Gaskill, 112 West Fourth St., Greenville, Ohio. Annual convention at New York City, June 10-12.

Northwest Electric Light & Power Association. C. H. Gueffroy, Pacific Power & Light Co., Portland, Ore. Convention at Gearhart Hotel, Gearhart, Ore., June 25-27.

Ohio Electric Light Association. D. L. Gaskill, Greenville, Ohio. Annual meeting at Hotel Breakers, Cedar Point, Ohio, July 8-11.

Society for the Promotion of Engineering Education. Charles F. Scott, University of Pittsburgh, Pittsburgh, Pa. Annual meeting, University of Colorado, Boulder, Colo., June 25-28.

World Power Conference. O. C. Merrill, Federal Power Commission, Washington, D. C. British Empire Exhibition, Wembley, London, June 30-July 12.

Trade Catalogs

Lubrication — McCord Radiator & Manufacturing Co., Detroit, Mich. Booklet "The Dependable Operation of Steam Shovels, Cranes and Dredges," contains a detailed description and many illustrations of its force feed lubricator. Price lists are included.

Drive, Chain—Ramsey Chain Co., Inc., Albany, N. Y. "Power Transmission with Ramsey Silent Chain," is a 45-page booklet containing information concerning this chain drive. It also includes tables on chain speed dimensions, chain length, price lists of sprockets, etc.

Instruments, Precision — Westinghouse Electric & Manufacturing Co., Newark, N. J. Folder No. 4603 is devoted to the description of the construction, operation and performance of precision voltmeters, ammeters and wattmeters manufactured by that company.

Brass—Chase Metal Works, Waterbury, Conn. Booklet "How to Order Brass," takes up the characteristics of brass with regard to its different alloys and tempers, gives names and differences of tempers and tables of common uses and tempers of wrought-copper alloys and tables of tolerances.

Oil-Burning Furnace—Marion Machine Foundry & Supply Co., Marion, Ind. Catalog No. 130 gives information concerning this oil-burning furnace and air indicator designed and developed by W. R. Pender, Houston, Tex. Descriptions and illustrations of installations and construction of the equipment are included.

Fittings, Pipe Structure—The Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa. Circular 1676 describes these fittings and gives their application to such work as the erection of outdoor substations, switching equipment, switchboard frames, racks, railings, etc. It is well illustrated and gives tables of dimensions.

Pyrometers—The Brown Instrument Co., Philadelphia, Pa. "Instructions for Installation and Care of Thermo-Electric Pyrometers," is a 72-page book covering the theory, installation and wiring of pyrometers. It contains tables of temperature millivolt equivalents for thermocouples and conversion of Fahrenheit and Centigrade scales.

Temperature Measuring Instruments—Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa. Bulletin No. 871 No. 1 Power Plant Series, "Temperature Measurements in Generators. Transformers and Cable Systems," gives, besides a general survey of the subject, descriptions, price lists and illustrations of instruments used in temperature measurements.

Condenser Tubes—Scovil Manufacturing Co., Waterbury, Conn. Booklet giving a non-technical description of the cupping process and other operations in the manufacture of seamless "Admiralty," and "Muntz Metal Tubes," has just been issued by this company. Two pamphlets containing specifica-

tions for these types of condenser tubes are also available.

Motors — Chandeysson Electric Co., St. Louis, Mo. Bulletin D-2 covers direct-current motors, Type D, 1 to 100 hp. Bulletin A-2 covers squirrel-cage alternating-current motors, Type A, 1 to 100 hp. Bulletin AD-2 is about motor generator sets, Type AD, 1 to 75 kw. All the bulletins are well illustrated and filled with useful information.

Coal and Ash Handling Machinery—The Jeffrey Manufacturing Co., Columbus, Ohio. Catalog No. 385, which covers power-house equipment, is arranged in twelve sections fully illustrated and with tables of specifications and dimensions covering pivoted bucket carrier, V-bucket conveyor, bucket elevators, weigh larries, track hoppers, plate feeders and bin valves, scraper conveyors, belt conveyors, steel apron conveyors, pan and spiral conveyors, skip hoists, crushers, and coal-storage equipment. The catalog is bound in stiff boards and contains an index.

Fuel Prices

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine run bases, f.o.b. mines):

Coal	Market Quoting	May 26, 1924	June 2, 1924
Pool 1	New York	$2.85	$3.00
Smokeless	Columbus	2.40	2.40
Clearfield	Boston	2.35	2.35
Somerset	Boston	2.50	2.50
Kanawha	Columbus	....	....
Hocking	Columbus	1.75	1.85
Pittsburgh No. 8	Cleveland	1.90	1.90
Franklin, Ill.	Chicago	2.50	2.50
Central, Ill.	Chicago	2.25	2.25
Ind. 4th Vein	Chicago	2.50	2.50
West Ky.	Louisville	1.75	1.75
S. E. Ky.	Louisville	1.75	1.75
Big Seam	Birmingham	2.25	2.00

FUEL OIL

New York—June 5, light oil, tank-car lots, 28@34 deg. Baumé, 5½c. per gal., 36@40 deg. 6c. per gal., f.o.b. Bayonne, N. J.

St. Louis—May 27, tank-car lots, f.o.b. St. Louis; 24@26 deg., $1.60 per bbl.; 26@28 deg., $1.65 per bbl.; 28@30 deg., $1.70 per bbl.; 32@36 deg., gas oil, 4½c. per gal.; 38@40 deg. 5½c. per gal.

Pittsburgh—May 26, f.o.b. local refinery, 30@34 deg., fuel oil, 5¼c. per gal.; 36@40 deg., fuel oil, 5½c. per gal.; 34 deg., neutral, 8½c. per gal.

Dallas—May 31, f.o.b. local refinery, 26@30 deg., $1.30@$1.35 per bbl.

Philadelphia—May 29, 28@30 deg., $2.31@$2.373 per bbl.; 18@22 deg., $2.10@$2.16½; 13@16 deg., $1.785@$1.848 per bbl.

Boston—May 29, tank-car lots, f.o.b. heavy oil, 12@14 deg. Baumé, 4⅜c. per gal., light oil, 28@32 deg., Baumé, 6¾c. per gal.

Cincinnati—June 3, tank-car lots, f.o.b. local refinery, 24@26 deg. Baumé, 4¾c. per gal.; 26@30 deg., 5¼c. per gal.; 30@32 deg., 5⅝c. per gal.

New Plant Construction

Ala., Florence—The United States Engineer will take bids until June 18, for screens, head gates, roller trains and other mechanisms for the power house at the Wilson Dam, Tennessee River, as per specifications on file.

Ala., Huntsville—The Common Council is considering centrifugal pumping equipment for proposed extensions and improvements in the municipal waterworks. A fund of $100,000, has been arranged.

Ariz., Winslow—The Atchison, Topeka & Santa Fe Railway Co., Los Angeles, Calif., is planning for a local ice-manufacturing plant, precooling station and icing dock, to cost $500,000, with machinery.

Ariz., Yuma—The Mohawk Valley Irrigation District, L. A. Macy and J. L. Terry, directors, is planning for a series of pumping plants for an irrigation project for 30,000 acres of land, to cost $750,000.

Calif., Bakersfield—The Richfield Oil Co. plans for pumping equipment and steam power apparatus in connection with the rebuilding of its refining plant, recently burned with loss of $250,000. The reconstruction will cost a like amount. A. M. Kelley, local manager.

Calif., Burbank — The Board of City Trustees plans for three electric-operated pumping plants, for proposed extensions and improvements in sewerage system. Plans have been prepared by Olmsted & Gillelen, Hollingsworth Bldg., Los Angeles. Arthur J. Rose, city engineer.

Calif., Exeter—The Board of City Trustees plans for centrifugal pumping equipment for a new sewerage system. A large septic tank will be installed. Bids will soon be asked.

Calif., Los Angeles—An isolated steam plant for heating and power service will be installed at the new building of the French Hospital Association on College St., near North Broadway. The entire project will cost $100,000. Thomas F. Power, 2615 West Seventh St., architect.

Calif., Los Angeles — The Little Rock Power & Water Co. has made application to the State Department of Public Works for a hydro-electric development on Little Rock Creek, Los Angeles County. The initial plant will have a capacity of 6,100 hp. Cost $600,000, with equipment.

Calif., Los Angeles—A power plant will be erected at the new bakery of the Davis Standard Baking Co., Los Angeles, at 1058 Mignonette St., for which plans are being completed. Electric ovens, conveying equipment and other mechanical apparatus will be installed. The entire plant will cost $100,000. C. C. Ruppenthal, 1025 West Washington Blvd., architect.

Calif., Oxnard—The Board of City Trustees is planning for deep well pumping equipment for municipal water service. A bond issue is being arranged. Bids will soon be asked.

Calif., Santa Barbara—The City Council has tentative plans for its proposed hydro-electric power station near the Gibraltar Dam, comprising two units, each 75 hp., to be used for municipal pumping service, etc., in accordance with recommendations made by Herbert Nunn, city manager.

Calif., Tiburon—The Bureau of Yards and Docks, Navy Department, Washington, D. C., has plans and will soon take bids for extensions and improvements in the coaling plant at the local naval base, as per Specification 4989.

Calif., Tulare—The Board of City Trustees is considering a pumping station for a proposed sewerage plant and system, to cost $190,000. The Elrod Engineering Co., Mills-Fraser Bldg., Santa Monica, Cal., is engineer.

Cuba, Guantanamo—The Bureau of Yards and Docks, Navy Department, Washington, D. C., has completed plans and will take bids at once for a steel water tank and auxiliary equipment at the local naval base, as per Specification 4977.

D. C., Washington—Bids will be received by the Bureau of Supplies and Accounts, Navy Department, until June 17, for a quantity of magnesia pipe covering and kindred equipment for various navy yards, as per Schedule 2241.

D. C., Washington—Bids will be received by the supervising architect, Treasury Department, until June 17, for the installation of a ventilating system in the Treasury Building, as per plans on file.

D. C., Washington—The general purchasing officer, Panama Canal, will take bids until June 19, for pumps, fans, steel pipe and points, valves, cocks, chain blocks and other engineering equipment, as called for in Circular 1613.

Fla., Bradentown—The Southern Utilities Co. has purchased a site on the Manatee River, for its proposed steam electric power plant, to include the installation of 3 turbo-generators, and accessory equipment. It will cost $200,000. T. D. Hayes, general manager.

Fla., Jacksonville—A boiler plant will be installed in the temple building for the Ancient and Accepted Scottish Rite organization. Plans have been drawn by Ray A. Benjamin, Jacksonville, architect. The structure will cost $300,000.

Fla., South Jacksonville—The City Council plans for a bond issue of $350,000 for municipal improvements. Part of the fund to be used for extensions, etc., in the municipal electric light and power plant.

Fla., Miami—The Miami Electric Light & Power Co. is arranging for extensions and improvements in power plant and lines. It is expected to develop a fund of more than $1,000,000. H. H. Hyman, general manager.

Ga., Cedartown—The United States Finishing Co. plans for extensions and improvements in the steam plant at its textile mill, to increase the capacity to 1,000 hp. Boilers and auxiliary equipment will be installed. Robert & Co., Inc., Atlanta, Ga., engineer.

Ga., Columbus—The City Water Commission has arranged an improvement program for the municipal waterworks during the present year, to include additional pumping equipment. W. J. Wood, chairman.

Ga., Helena—The Telfair Ice Co., recently organized, will immediately erect an ice-manufacturing plant. M. E. Pittman, general manager.

Idaho, Idaho Falls—The Utah Power & Light Co., Salt Lake City, Utah, has made application for permission to proceed with a hydro-electric power project on the Bear River.

Ind., Indianapolis—Kingan & Co., operating a meat-packing plant, will break ground at once for a cold storage and refrigerating plant at Georgia and Blackford Sts., to cost $200,000, with equipment.

Iowa, Brighton—The Town Council plans for the purchase of a fuel oil engine, about 50 hp., with accessory equipment. O. F. Mangold, councilman, in charge.

Kan., Independence—The City Council is having plans completed and expects to take bids soon for a pumping plant in connection with extensions in the sewerage system. G. H. Hackmaster is engineer. The entire project will cost $37,000.

Kan., Winfield—The Winfield Ice Co. is completing plans and will take bids around June 16, for extensions and improvements in its ice plant, estimated to cost $27,000. I. M. Fuller, Cowley County Bank Bldg., Winfield, architect.

La., Donaldsonville—The Municipal Light and Water Commission has preliminary plans for additional pumping machinery in connection with extensions in the water system.

Md., Baltimore—The Seaboard Terminal Corp., represented by Jerome Sloman, Union Trust Bldg., attorney, plans for a steam power plant and pumping station at its oil refinery and distributing plant in the Curtis Bay district. Plans are in progress. The entire project will involve $1,000,000.

Md., Berlin—The Common Council is arranging for extensions and improvements in the municipal electric light and power station, estimated to cost $10,000. The Chamber of Commerce is interested in the project.

Mass., Boston—William G. Barry plans for the rebuilding of the portion of his boiler plant and rock-crushing plant near Ashland St., West Roxbury, burned May 29, with loss of $30,000, including equipment.

Mass., Cambridge—The Cambridge Gas Light Co., Massachusetts Ave., will make extensions and improvements in its boiler plant at 354 Third St., to cost $45,000, with equipment. Plans have been completed and work will soon begin.

Mass., Rutland — The director, United States Veterans' Bureau, Arlington Bldg., Washington, D. C., will take bids until June 24, for a sewerage pumping station in connection with other work at the United States Veterans' Hospital, as per plans and specifications on file.

Mass., West Newton—F. J. Fessenden, 216 Albermarle Rd., has filed plans for a boiler plant on street noted to cost $20,000, for local industrial service. Shepard & Stearns, 65 Franklin St., Boston, architects.

Mich., Blissfield—The Common Council plans for centrifugal pumping machinery, for a proposed waterworks plant and system. Bonds for $130,000 have been approved.

Mich., Jackson—The city clerk is taking bids until July 2 for a high-service pumping plant at the municipal waterworks, including boiler house, coal trestle, etc., as per plans and specifications on file. J. E. Whittaker is city manager.

Mich., Mount Morris—E. J. Roberson, 502 Genesee Bank Bldg., Flint, Mich., is at the head of a project to construct and operate a plant for the manufacture of caskets, to include a boiler house. It is estimated to cost $200,000. A company is being organized.

Mich., St. Joseph — J. J. Theisen and Charles K. Warren, Three Oaks, Mich., plan for a boiler plant at their proposed brick manufacturing plant, to cost $100,000, complete. A mechanical drying system will also be installed.

Minn., Albert Lea—The Southern Minnesota Gas & Electric Co. has filed plans for an addition to its generating plant on Newton St., including boilers and other equipment.

Minn., Owatonna—The City Council has had surveys made and will soon approve plans for municipal steam electric power plant, to cost about $350,000. The installation will include turbo-generators, two 300 hp. watertube boilers, and auxiliary apparatus, with spray nozzle cooling system, water-treating plant, etc. A reinforced-concrete stack will be built 130 ft. high. Jacobson & Jacobson, Northwestern National Life Bldg., Minneapolis, Minn., engineers. C. J. Servatius, city clerk.

Miss., Poplarville—The R. J. Williams Lumber Co. plans for the rebuilding of the portion of its mill and steam power house, burned on May 23, with loss of $200,000, including equipment.

Miss., Tupelo—The Mississippi Light & Power Co. plans for a turbo-generator and auxiliary equipment at the power plant of the Tupelo Cotton Mills, recently acquired for central station service. It is expected to advance the capacity by 500 hp. Headquarters of the company are at Pine Bluff, Ark.

Mo., Columbia—The Polar Wave Ice Co., 3654 Olive St., St. Louis, has preliminary plans for an ice and cold storage plant at Columbia, to cost $200,000, with equipment. H. G. Clymer, Wainright Bldg., St. Louis, architect.

Neb., Friend—The Village Council contemplates centrifugal pumping equipment in connection with a sewerage system. Plans are being prepared by H. A. Davis, Crete, Neb., engineer.

Neb., Louisville—Plans are under consideration by the Village Council for a pumping station in connection with a sewerage system. Plans are nearing completion.

N. M., Estancia—J. M. Land, El Paso, Tex., engineer, is at the head of a project to construct and operate a light and power plant for commercial service, to cost $50,000.

N. M., Estancia—The State Engineering Department, Santa Fe, is considering pumping equipment for a proposed water supply system. An appropriation of $25,000, is available.

N. M., Las Cruces—Stone & Webster, Inc., 147 Milk St., Boston, Mass., plans for extensions and improvements in the light and power plant and system of the Las Cruces Electric Light & Ice Co., recently acquired, estimated to cost about $150,000. During the next 36 to 48 months, it is purposed to expend close to $500,000, in this district.

N. Y., Binghamton—The Board of Contract and Supply, City Hall, is completing plans and will soon take bids for a power house in connection with an addition to the city hospital. The entire project will cost $650,000. Walter Whitlock, Security Bldg., Binghamton, architects; A. R. Acheson, Eckel Theater Bldg., Syracuse, N. Y., steam and electric engineer.

N. Y., Buffalo—The Derbrah Silk Corp., Military Rd. and Skillen St., has taken out a permit for a steam power plant at its new silk mill. The entire project will cost $110,000.

N. Y., Burdette — The local municipal electric plant has been leased for a period of years by the Elmira Water, Light & Railroad Co., Elmira, N. Y., which will furnish service in this section in the future. Extensions are planned.

N. Y., Montgomery—William Crabtree & Sons are planning for two additional boilers and auxiliary equipment at their power house, used for textile mill service.

N. Y., Rome — The County Board of Supervisors, Charles A. G. Scotham, County Court House, Utica, purchasing agent, plans for a new refrigerating plant at the Oneida County Home, and will begin work soon.

N. C., Biltmore—The Williams-Brownell Planing Mill Co. is planning for the rebuilding of the portion of its boiler plant recently burned. Estimate of loss has not been announced.

N. C., Shelby—Z. T. Thompson, North Washington St., contemplates a boiler house for his proposed woodworking plant. Plans are being arranged. The entire works will cost $25,000.

N. C., Stantonsburg—The Common Council is planning for centrifugal pumping equipment in connection with extensions and improvements in the water and sewerage systems, for which it is proposed to issue bonds for $47,000.

N. C., Star—The Common Council plans for a bond issue of $85,000, for its municipal waterworks, to include a pumping station. Beebe & Co., Spartanburg, S. C., engineers.

Pa., Johnstown — The Youghiogheny Hydro-Electric Corp., affiliated with the Penn Public Service Corp., Johnstown, is disposing of a bond issue of $2,750,000, a part of which is to be used for a hydro-electric generating plant on the Youghiogheny River in Western Maryland, to develop an initial capacity of 24,000 kw. Work has been started. F. T. Hepburn, president.

Pa., Kane — The Pennsylvania Plate Glass Co., recently organized by W. A. James, Kane, and associates, with capital of $750,000, plans for a power plant at its sheet glass works. Plans will soon be drawn. The entire project is estimated to cost $400,000.

Pa., Philadelphia—The Philadelphia Electric Co., Tenth and Chestnut Sts., plans for early awards of contracts for equipment for its steam generating plant at the foot of Erie Ave., Delaware River. Building foundations are in progress. Contract for two 50,000 kw. generators has been let to the General Electric Co. The plant will cost $5,000,000.

Pa., Philadelphia—The Water Commission, City Hall, plans an appropriation of $13,500,000 for extensions in the municipal waterworks for a new source of supply, including pumping stations and auxiliary equipment. The Bureau of Water will be in charge.

Philippine Island, Cavite—The Bureau of Yards and Docks, Navy Department, Washington, D. C., has plans and will soon ask bids for extensions and improvements in the coaling plant at the naval base, as per Specification 4990.

S. C., Fort Mill—The Southern Power Co., Charlotte, N. C., is planning for enlargements in its hydro-electric plant on the Catawba River, with additional equipment, increase in power dam, etc., to cost $450,000.

S. D., Sioux Falls—The Common Council plans and will soon take bids for an addition to the municipal power plant. It is understood that certain equipment has been purchased. Joseph Schwarz, Minnehaha Bldg., architect.

S. C., Spartanburg—The Board of Water Commissioners plans for a hydro-electric power plant in connection with a new water system, using supply from the South Pacolet River. A pumping station will also be installed. The entire project to cost $1,300,000. Paul Norcross, Atlanta, Ga., consulting engineer.

S. D., Menno—The Northwestern Public Service Co., Huron, S. D., has acquired the power plant and system, heretofore operated by the Mettler Brothers Light Co. Extensions and improvements will be made, including new a.c. equipment, to replace d.c. apparatus.

Tenn., Cookville—The city clerk will soon take bids for a pumping plant, for proposed extensions and improvements in the municipal waterworks, to cost $150,000. V. V. Long & Co., Oklahoma City, Okla., engineers.

Tenn., Dresden—The Kentucky-Tennessee Power Co., has acquired the municipal electric power plant, and will furnish service in the future. Extensions will be made.

Tex., Breckenridge—The Westover Oil & Gas Co., operated by the Hope Engineering & Supply Co., Farmers' Bank Bldg., Pittsburgh, Pa., plans for air compressors, boilers and other equipment at its gasoline refining plant, to cost $450,000.

Tex., Cleburne—The Common Council has plans for a municipal electric light and power plant. It is expected to arrange an appropriation soon.

Tex., Dallas—The Hilton Hotel Co., N. C. Hilton, president, will install a steam plant and refrigerating plant in its proposed hotel at Main and Harwood Sts., estimated to cost $1,000,000, for which bids will soon be asked. Lang & Witchell, Dallas, architects.

Tex., Goldthwaite—The Common Council has tentative plans for a municipal ice and cold storage plant. The Chamber of Commerce is interested.

Tex., Irving—The Fresh Water District, Louis Hancock, secretary, plans for a pumping station for its water system. Plans are being prepared by Koch & Fowler, Central Bank Bldg., Dallas, engineers.

Tex., Kerens—The Texas Power & Light Co. has purchased the property of the Kerens Light & Power Co., and will consolidate with its system. Plans are under way for extensions and improvements in station and lines.

Tex., San Antonio—The Planters' & Manufacturers' Cotton Mill Co., lately organized with a capital of $3,000,000, has commissioned Lockwood, Greene & Co., 24 Federal St., Boston, Mass. and Charlotte, N. C., architects and engineers, to prepare plans for its proposed mills at San Antonio, Austin and San Marcos, Tex. Steam plants will be installed at each of the different units, with total cost of projects $2,000,000. S. M. Ramsopher, head of the Planters' & Merchants' Mill, New Braunfels, Tex., president of the new company.

Tex., Sisco—The Common Council is planning for centrifugal pumping machinery for extensions and improvements in the municipal waterworks. The entire project will cost $50,000. The Elrod Engineering Co., 3124 Main St., Dallas, engineer.

Va., Harrisonburg—The Board of Public Works plans for reconstruction and improvements at the municipal hydro-electric plant on the Shenandoah River, to cost $70,000. John F. Noll, superintendent.

Va., Norfolk—The Ford Motor Co., Highland Park, Detroit, Mich., is making ready to proceed with its local assembling plant, with steam-power station, on tract of 40 acres of land recently acquired. The entire project to cost $1,000,000.

Va., Portsmouth—J. P. Jervey, city manager, will soon call for bids for two new pumping stations for the municipal sewerage system, including the installation of equipment. It is understood that centrifugal pumping units will be installed.

Va., Richmond—The Francioni Estate, represented by Homer Wilson of Schmidt & Wilson, Inc., Richmond, plans for a steam plant and refrigerating plant in its fifteen-story hotel to be erected at Broad and Ninth Sts. Plans are being drawn by W. L. Stoddart, 50 East Forty-first St., New York, architect.

Wash., Tacoma—The City Council has authorized the purchase of equipment for improvements in the La Grande municipal power station.

Wash., Seattle—The Campbell Lumber Co. has plans for the rebuilding of the portion of its mill and central steam power house on Lake Sammamish, near Seattle, recently burned with loss of $350,000, including equipment.

W. Va., Excelsior—The Low Ash Mining Co. plans for the rebuilding of the portion of its power plant, recently burned with loss estimated at $15,000.

Wis., Chippewa Falls—The County Commissioners have rejected bids, recently received, for a new boiler plant at the county asylum, and will take new bids on revised plans at an early date. James R. Harris, county clerk.

PRICES - MATERIALS - SUPPLIES

Electrical prices on following page are prices to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

SINCE LAST MONTH

Price declines predominate in power plant and electrical supplies in the current market. The two principal advances occurring during the month were a rise of 3c. per gal. in raw linseed oil in New York and an increase of 15c. per package in fuse plugs. The declines occurred in boiler rivets, babbitt metal, wiping cloths, hose, rubber belting and armored cable.

POWER-PLANT SUPPLIES

HOSE—

	Fire Protection	50-Ft. Lengths
Underwriters' 2½-in., coupled, single jacket		56c. per ft.
Common, 2½-in., 3-ply	80c. per ft. list less	50–10%

Air—Best grade

½-in., per ft.	3-ply	$0 36	4 ply	$0.44½

Steam—Discounts from List

First grade	30–5%	Second grade	40–5%	Third grade 50%

RUBBER BELTING—The following discounts from list apply to rubber transmission belting:

Best grade	50%	Second grade	50–10%

LEATHER BELTING—List price, 24c. per lin.ft. per inch of width for single ply.

Grade	Discount from list
Medium	40–2½%
Heavy	30–5%

RAWHIDE LACING { For cut, best grade, 45–5%, 2nd grade, 55%. For laces in sides, best, 41c. per sq.ft.; 2nd, 37c. Semi-tanned: cut, 45–5%; sides, 41c. per sq.ft.

PACKING—Prices per pound:

Rubber and duck for low-pressure steam, ½ in.	$0.90
Asbestos for high-pressure steam, ½ in.	1.70
Duck and rubber for piston packing	.90
Flax, regular	1.10
Flax, waterproofed	1.70
Compressed asbestos sheet	.80
Wire insertion asbestos sheet	1.30
Rubber sheet	.45
Rubber sheet, wire insertion	.70
Rubber sheet, duck insertion	.50
Rubber sheet, cloth insertion	.25
Asbestos packing, twisted or braided and graphited, for valve stems and stuffing boxes	1.30
Asbestos wick, ½- and 1-lb. balls	50

PIPE AND BOILER COVERING—Discounts, New York warehouses, are as follows:

85% magnesia high pressure		50%
For low-pressure heating and return lines	4-ply	70%
	3-ply	72%
	2-ply	74%

PORTLAND CEMENT—New York, $2.50@ $2.60 per bbl. without bags, in carload lots delivered on job. Bag charge of 40c. per bbl.

STRUCTURAL STEEL—New York delivered price, 3 to 15-in. beams and channels and 3 to 6-in. angles, tees, and plates, all $3.59 per 100 lb.

COTTON WASTE—The following prices are in cents per pound:

	New York	Cleveland	Chicago
White	14@21	20.00	14.00
Colored	9@12.50	17.00	10.50

WIPING CLOTHS—Jobbers' prices, in cents per lb., as follows:

	13¼ x 13¼	13¼ x 20½
Chicago	16.00	16.00
New York (white, at washeries)	10 75	
Cleveland	$36.00 per M.	$52.00 per M.

LINSEED OIL—These prices are per gallon:

	New York	Cleveland	Chicago
Raw in barrels (5 bbl. lots)	$0.98	$1.07	$0.94

WHITE AND RED LEAD—In 100-lb. kegs, base price in cents per pound:

	Dry		In Oil	
	Current	1 Yr. Ago	Current	1 Yr. Ago
Red	15.00	14.50	16.50	16.00
White	15.00	14.50	15.00	14.50

RIVETS—The following quotations are allowed for fair-sized orders from warehouse:

	New York	Cleveland	Chicago
Steel ⅞ and smaller	50%	60–10%	60%
Tinned	50%	60–10%	4½c. per lb. net

Structural rivets, ½, ⅝, 1 in. diameter by 2 in. to 5 in. sell as follows per 100 lb.

New York	$4.00	Chicago	$3.75	Pittsburgh	$2.60@$2.75
Boiler rivets, same sizes:						
New York	$4.10	Chicago	$3.85	Pittsburgh	$3.00

REFRACTORIES—Prices in car lots f.o.b. plant:

Chrome brick, eastern shipping points	net ton	$47@52
Chrome cement, 40@ 50% Cr_2O_3, in bulk	net ton	22@27
Chrome cement, 40@ 50% Cr_2O_3, in sacks	net ton	26@31
Magnesite brick: 9-in. straights	net ton	65@68
Magnesite brick: 9-in. arches, wedges and keys	net ton	71.50@74.80
Magnesite brick: Soaps and spits	per ton	91.00@95.20
Silica brick: Mt. Union, Pa.	per M	38@40
Clay brick, 1st quality, 9 in. shapes, Pennsylvania	per M	41@48
Clay brick, 1st quality, 9 in. shapes, Ohio	per M	40@43
Clay brick, 1st quality, 9 in. shapes, Kentucky	per M	42@43
Clay brick, 2nd quality, 9 in. shapes, Pennsylvania	per M	36@43
Clay brick, 2nd quality, 9 in. shapes, Ohio	per M	37@39
Clay brick, 2nd quality, 9 in. shapes, Kentucky	per M	37@39
Chrome ore crude, 40@50%	net ton	17.00@19.50

BABBITT METAL—Warehouse prices in cents per pound:

	New York	Cleveland	Chicago
(83% tin)	60.00	53.00	48@52
(35% tin)	28.00	17.50	23@26

COLD DRAWN STEEL—Warehouse prices are as follows:

	New York	Cleveland	Chicago
Round shafting and screw stock, per 100 lb. base	$4.40	$4.10	$4.00
Flats, square and hexagons, per 100 lb. base	4.90	4.60	4.50

BOILER SPECIALTIES—F. o. b. New York or Jersey City, discounts on list:

	Current
Copper ferrules	70%
Boiler flanges	60-10%
Boiler stay bolts	60%
Boiler patch bolts	10%
Boiler fitting-up bolts	45%
Pressed steel boiler lugs	10%
Pressed steel boiler hangers	10%

WROUGHT PIPE—The following discounts are to jobbers for carload lots on the latest Pittsburgh basing card:

BUTT WELD

Inches	Steel Black	Steel Galv.	Inches	Iron Black	Iron Galv.
1 to 3	62	50½	1 to 1½	30	13

LAP WELD

2	55	43½	2	23	7
2½ to 6	59	47½	2½	26	11
7 and 8	56	43½	3 to 6	28	13
9 and 10	54	41½	7 to 12	26	11
11 and 12	53	40½			

BUTT WELD, EXTRA STRONG, PLAIN ENDS

1 to 1½	60	49½	1 to 1½	30	14
2 and 3	61	50½			

LAP WELD, EXTRA STRONG, PLAIN ENDS

2	53	42½	2	23	9
2½ to 4	57	46½	2½ to 4	29	15
4½ to 6	56	45½	4½ to 6	28	14
7 and 8	52	39½	7 and 8	21	7
9 and 10	45	32½	9 to 12	16	2
11 and 12	44	31½			

BOILER TUBES—Following are prices in New York warehouse of tubes manufactured according to specifications of the American Society of Mechanical Engineers:

Size	Lapweld Steel	C. C. Iron	Seamless Steel
1	.....	.....	$0.23
1¼	.....	.....	.25
1½	.....	.....	.22
1¾	$0.26	$0.29	.23
2	.20	.25	.21
2¼	.23	.29	.23
2½	.24	.33	.28
2¾	.....	.....	.....
3	.30	.41	.32
3¼	.32	.47	.35
3½	.34	.51	.37
4	.43	.64	.47

Tubes 2½ in. diameter, or smaller, over 18 ft. long, 10 per cent extra.

These prices are net per lineal foot based on stock lengths. If cut to special lengths, billing will be based on the entire stock lengths.

In addition to the above, standard cutting charges are as follows:

1¼ in. to 2 in. diameter, 5c. per cut. 2½ in. diameter, 7c. per cut
2¾ in. diameter, 6c. per cut. 3 in. diameter, 9c. per cut
3¼ in. to 4 in. diameter, 10c.

ELECTRICAL SUPPLIES

ARMORED CABLE—Price per 1,000 ft.—5 per cent 10 days.

B. & S. Size	Two Cond. M Ft.	Three Cond. M Ft.	Two Cond. Lead M Ft.	Three Cond. Lead M Ft.
No. 14 solid	$42.00 (net)	$ 65.00 (net)	$164.00	$210.00
No. 12 solid	135.00	170.00	225.00	265.00
No. 10 solid	185.00	235.00	275.00	325.00
No. 8 stranded	285.00	375.00	520.00	500.00
No. 6 stranded	400.00	500.00	560.00	.....

From the above lists discounts are:		Lead Covered
Less than coil lots	35%	20%
Coils to 1,000 ft.	45%	25%
1,000 to 5,000 ft.	50%	30%
5,000 ft. and over	55%	35%

CONDUIT, Price per 1,000 ft.; **ELBOWS AND COUPLINGS**, Per 100 pieces, f.o.b. New York, with 10-day discount of 5 per cent.

Size In.	Conduit Black Per M	Conduit Galvanized Per M	Elbows Black Per C	Elbows Galvanized Per C	Couplings Black Per C	Couplings Galvanized Per C
¾	$61.10	$66.16	$9.90	$11.03	$5.74	$6.16
¾	79.20	84.95	13.00	14.49	8.18	8.78
1	112.06	122.19	19.26	21.46	10.65	11.42
1¼	151.62	165.31	25.65	28.33	14.76	15.78
1½	181.28	197.67	34.19	37.77	18.23	19.47
2	248.90	265.94	62.70	69.24	24.29	25.97
2½	385.50	420.48	102.58	111.33	34.71	37.10
3	504.29	548.81	273.40	302.12	51.66	55.63
3½	633.86	688.65	604.03	667.15	69.41	74.19
4	772.62	838.59	697.06	770.99	86.76	92.73

CONDUIT BODIES AND FITTINGS—Black or galvanized.

	Less than $10 list	$10 list to $100	$100 list and over
Standard package	10%	20%	28%
Less than standard package	5%	10%	20%

CUT-OUTS—Following are net prices each in standard-package quantities·

CUT-OUTS, PLUG

S. P. M. L.	$0.12	D. P. D. B.	$0.31
D. P. M. L.	.16	T. P. S. B.	.35
T. P. M. L.	.27	T. P. D. B.	.47
D. P. S. B.	.16		

CUT-OUTS, N. E. C. FUSE

	0-30 Amp.	31-60 Amp.	60-100 Amp.
D. P. M. L.	$0.27	$0.70	$1.75
T. P. M. L.	.40	1.00	2.30
D. P. S. B.	.35	.87	.....
T. P. S. B.	.67	1.50	.....
D. P. D. B.	.65	1.75	.....
T. P. D. B.	1.12	3.00	.....
T. P. to D. P. D. B.	.75	2.10	.....

FLEXIBLE CORD—Price per 1,000 ft. in coils of 250 ft.:

No. 18 cotton reinforced heavy	$22.00
No. 16 cotton reinforced heavy	25.50
No. 18 cotton reinforced light	18.50
No. 16 cotton reinforced light	21.50
No. 18 cotton Canvasite cord	16.50
No. 16 cotton Canvasite cord	18.75

NATIONAL ELECTRIC CODE FUSES, NON-REFILLABLE—

250-Volt	Std. Pkg.	List	600-Volt	Std. Pkg.	List
3-amp. to 30-amp.	100	$0.15	3-amp. to 30-amp.	100	$0.30
35-amp. to 60-amp.	100	.30	35-amp. to 60-amp.	100	.60
61-amp. to 100-amp.	50	.90	65-amp. to 100-amp.	50	1.50
101-amp. to 200-amp.	25	2.00	110-amp. to 200-amp.	25	2.50
201-amp. to 400-amp.	25	3.60	225-amp. to 400-amp.	25	5.50
401-amp. to 600-amp.	10	5.50	450-amp. to 600-amp.	10	8.00

Discount: Less 1-5th standard package, 55%; 1-5th to standard package, 60%; standard package, 65%.

RENEWABLE FUSES, ENCLOSED—List price each:

Sizes	250-Volt List-Price	600-Volt List-Price	Std. Pkg. Quantity	Carton Quantity
1 to 30-amp.	$0.50	$1.10	100	10
35 to 60-amp.	1.00	1.25	100	10
65 to 100-amp.	2.00	3.00	50	5
110 to 200-amp.	4.00	5.00	25	5
225 to 400-amp.	7.50	11.00	25	1
450 to 600-amp.	11.00	16.00	10	1
450 to 600-amp	11.00	16.00	10	1

REFILLS—

1 to 30	$0.30 ea.	$0.05	100	100
35 to 60	.05 ea.	.06	100	100
65 to 100	.10 ea.	.10	50	50
110 to 200	.15 ea.	.15	25	50
225 to 400	.30 ea.	.30	25	25
450 to 600	.60 ea.	.60	10	10

Discount Without Contract—Fuses:	
Broken carton	5%
Unbroken carton but less than std. pkg.	22%
Std. pkg.	40%
Discount Without Contract—Renewals:	
Less than std. pkg.	Net list
Standard package	40%
Discount With Contract—Fuses:	
Broken cartons	10%
Unbroken cartons but less than standard package	26%
Standard package	42%
Discount With Contract—Renewals:	
Less standard package	Net list
Standard package	42%

FUSE PLUGS, MICA CAP—

0-30 ampere, standard package (500)	$2.85
0-30 ampere, less than standard package	3.15

LAMPS—Below are present quotations in less than standard package quantities:

Straight-Side Bulbs Mazda B— Watts	Plain	Frosted	No. in Package	Pear-Shaped Bulbs or Bowl Enameled Mazda C— Watts	Clear	Frosted	No. in Package
10	$0.30	$0.35	120	50	$0.45	$0.50	60
15	.30	.35	120	75	.50	.55	60
25	.30	.35	120	100	.60	.65	24
40	.30	.35	120	150	.75	.80	24
50	.30	.35	120	200	1.00	1.10	24
60	.35	.40	120	300	1.60	1.70	24
				500	2.35	2.50	12
				750	3.75	3.95	8
				1,000	4.00	4.25	8

Standard quantities are subject to discount of 10% from list. Annual contracts ranging from $75.00 to $300,000 net allow a discount of 15 to 40% from list.

PLUGS, ATTACHMENT—

	Each
Porcelain separable attachment plug	$0.18
Composition 2-piece attachment plug	.27
Swivel attachment plug	.12
Composition—2 Pc. Plug—Composition	0.8½

RUBBER-COVERED COPPER WIRE—Per 1000 ft. f. o b. New York,

No.	Solid Single Braid	Solid Double Braid	Stranded, Double Braid	Duplex
14	$ 6.90	$7.30	$11.20	$17.80
12	9.20	12.40	13.75	23.40
10	12.50	16.00	17.40	30.10
8	17.60	21.30	22.75	39.40
6	.....	.....	33.00	.....
4	.....	.....	45.10	.....
2	.....	.....	64.50	.....
1	.....	.....	83.50	.....
0	.....	.....	114.00	.....
00	.....	.....	133.40	.....
000	.....	.....	162.80	.....
0000	.....	.....	193.00	.....

SOCKETS, BRASS SHELL—

½ In. or Pendant Cap Key Each	Keyless Each	Pull Each	¾ In. Cap Key Each	Keyless Each	Pull Each
$0.33	$0.30	$0.55	$0.39	$0.36	$0.61

Less 1-5th standard package	25%
1-5th to standard package	32%
Standard package	37%

WIRING SUPPLIES—

Friction tape, ¾ in., less 100 lb. 34c. lb., 100 lb. lots	33c lb.
Rubber tape, ¾ in., less 100 lb. 34c. lb., 100 lb. lots	33 lb.
Wire solder, less 100 lb. 27c. lb., 100 lb. lots	29c. lb.
Soldering paste, 2 oz. cans	$1.00 doz.

ENCLOSED SWITCHES, KNIFE—Safety type, externally operated, 250 d.c. or a.c., N E.C.

TYPE "C" FUSED BOTTOM

Size, Amp.	Double Pole, Each	Three Pole, Each	Four Pole, Each
30	$4.50	$6.00	$7.25
60	7.50	8.25	10.50
100	10.50	13.00	22.50
200	16.00	20.00	36.00

Discounts:	
Less than $25.00 list value	30%
$25 to $50 list value	30–5%
$50 list value or over	35%